RETHINKING FOOD SECURITY POLICY IN DEVELOPING COUNTRIES

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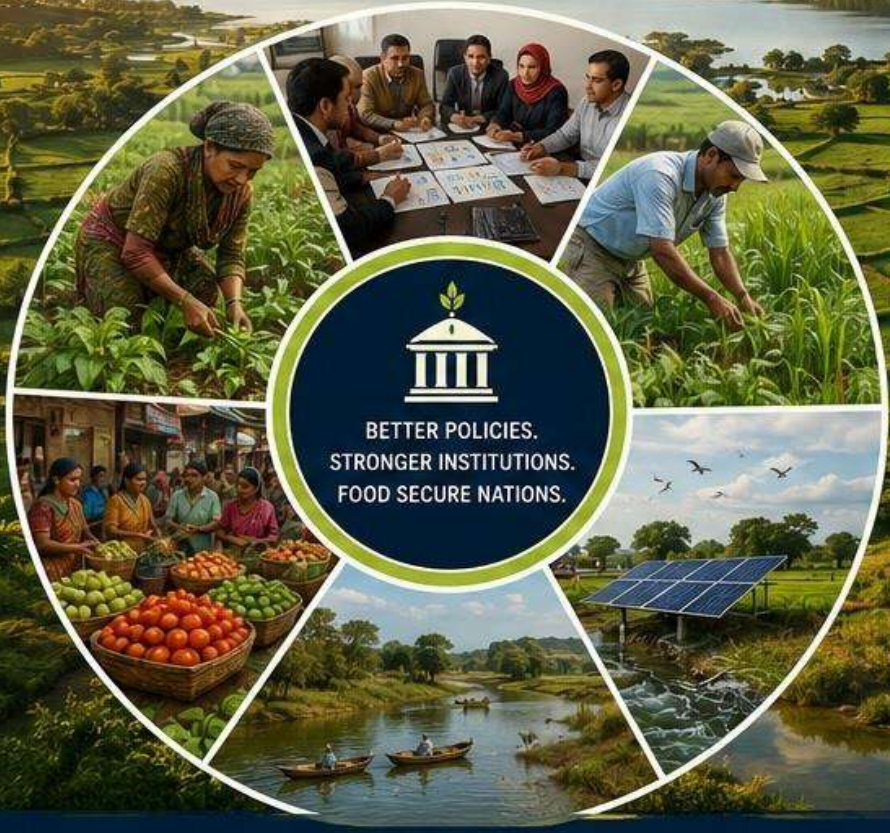

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Muhammad Khalid Bashir • Muhammad Umar Farrukh

RETHINKING FOOD SECURITY POLICIY IN DEVELOPING COUNTRIES

Muhammad Khalid Bashir[1,2,*]
Muhammad Umar Farrukh[3]

[1]Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad, Pakistan
[2]Policy, Advocacy, and Outreach, Pak-Korea Nutrition Center, University of Agriculture, Faisalabad, Pakistan
[3]Department of Economics, Government College Women University, Sialkot, Pakistan
Corresponding author's email: khalid450@uaf.edu.pk

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ABOUT THE AUTHORS

Muhammad Khalid Bsahir

Dr. Muhammad Khalid Bashir is a distinguished academic, researcher, and policy expert specializing in agricultural economics, food security, climate change, and rural development. With more than two decades of experience in teaching, research, and policy engagement, he has made significant contributions to advancing evidence-based solutions for sustainable agriculture and food systems in Pakistan and beyond. His research has informed food security policies, nutrition initiatives, and rural development strategies. His scholarly excellence has been recognized through the HEC Best Research Paper Award, HEC Best Young Researcher Award, the Pakistan Council for Science and Technology (PCST) Productivity Award, and the Express Media Group Teaching Award. He has also been recognized among the Top 1% of Reviewers worldwide by Clarivate, reflecting his international academic standing and commitment to research excellence.

Muhammad Umar Farrukh

Dr. Muhammad Umar Farrukh is an economist, academic, and researcher specializing in food security, agricultural economics, development economics, public policy, and sustainable economic growth. As an Assistant Professor of Economics, he is actively engaged in teaching, research, and policy-oriented initiatives addressing contemporary development challenges. His research explores the relationships among food systems, governance, rural transformation, and economic resilience, with particular emphasis on developing countries. He has contributed to evidence-based policymaking by examining strategies that strengthen food security, promote agricultural sustainability, enhance institutional effectiveness, and support inclusive development. His work advocates innovative approaches integrating governance, technological advancement, and human capital development to build resilient food systems and foster sustainable economic prosperity. Dr. Farrukh remains committed to producing impactful research that informs policy and improves livelihoods.

LIST OF CONTRIBUTORS

Abdullah Hammad
Adan Noor
Afsheen Aqeel
Ahmad Abdul Wahab
Ahmad Saleem
Ahras Rasheed
Amar Razaq
Amina Yaqoob
Ashir Kamal
Ayesha Noreen
Ayesha Rouf
Ayesha Wasti
Ayisha Aman Ullah
Burhan Ahmad
Faisal Munir
Farwa Tariq
Fasiha Batool
Hadia Islam
Hafiza Javeria Shehzadi
Hasan Zulfiqar
Iqra Alam
Irfan Ahmad
Irfan Hussain Khan
Kadir Akan
Kashif Hamid Boparai
Kinza Khaliq
Kiran Aslam
La Ode M. Aslan
Maliha Sarfraz
Mannan Aleem
Maryam Nawaz
Masood Ahmad Khan
Motiba Ghafoor
Muhammad Adeel Sattar
Muhammad Amjad Iqbal
Muhammad Asad ur Rehman Naseer
Muhammad Dildar Gogi
Muhammad Farooq Khalid
Muhammad Hafeez
Muhammad Hamid Bashir
Muhammad Haroon U Rashid
Muhammad Imran
Muhammad Imran Khan
Muhammad Khalid Bashir
Muhammad Shoaib Naseer
Muhammad Talha Arshad
Muhammad Umair Sial
Muhammad Umair Zulfiqar
Muhammad Umer Farrukh
Mustafa Kan
Naeem Saddique
Nazia Tabasam
Neelam Rana
Omar Abdullah Alkhateeb
Qaiser Ali
Qasir Abbas
Ramsha Akram
Ratna Diyah Palupi
Rehana Ali Naqvi
Roma Saleem
Saba Javed
Saba Shamim
Sabir Hussain
Saher Jabeen
Sajjad Hyder
Sania Shaheen
Sarah Aleem
Sharoon Aftab
Shoaib Akhtar
Shoaib Sarwar
Sidra Riaz
Siti Aida Adha Taridala
Syed Muhammad Subtain Abbas
Tahira Sadaf
Tamrin
Tayyab Ali
Umair Rafiq
Umamah Ahmed
Umar Aftab Abbasi
Umar Farooq
Usman Rianse
Wa Kuasa Baka
Yusuf Sabilu
Zaki Rauf
Zainab Razaq
Zamah Bukhari

PREFACE

This book began with a discomfort that neither of us could fully shake. Between us, we have spent the better part of two decades working on agricultural and resource economics in Pakistan and the wider South Asian region, teaching, advising, reviewing policy documents, and watching successive food security programs arrive with great fanfare and depart with little to show for themselves. The puzzle was never a shortage of effort. Governments invested. Donors funded. Researchers published. And yet hunger persisted, year after year, in the same districts, among the same categories of people, often despite measurable increases in national food production. At some point the explanation that production had simply not caught up with population stopped being credible. Something else was going on.

That something else, we came to believe, was governance: the institutions, incentives, and political arrangements that determine whether a subsidy reaches a smallholder or is captured along the way, whether a devolved mandate comes with the finance needed to discharge it, whether a price shock is cushioned by a functioning safety net or simply passed on to households already living close to the edge. This is not a novel insight in the abstract; development economists have argued versions of it for institutions and growth more generally. But it had not, in our reading of the food security literature, been pursued with sufficient depth or breadth specifically for food systems in developing economies, and it had certainly not been pursued in a way that took marine food systems, political economy dynamics, and decentralization equally seriously alongside the more familiar territory of agronomy and nutrition.

We therefore set out to assemble a volume that would put governance at the center rather than the margins of the food security conversation, and that would do so through the work of scholars who study these questions from the ground up, in their own countries and regions, rather than through a single authorial voice imposing a single national lens on a problem that is, by its nature, comparative. The contributors to this book work across South Asia, Southeast Asia, sub-Saharan Africa, Latin America, and Europe, and they bring with them methods ranging from systematic review and time-series econometrics to political economy case analysis and primary survey work. What unites their otherwise quite different chapters is a shared willingness to ask not only what food security outcomes look like, but why the institutions responsible for producing those outcomes behave the way they do.

Readers will find in the chapters that follow an unusual combination of attention to marine food systems alongside terrestrial agriculture, to the everyday politics of subsidy and procurement reform alongside the technical apparatus of price volatility modelling, and to the household-level behavior of food waste alongside the national-level architecture of policy learning. We have tried, as editors, to preserve the distinct voice and disciplinary grounding of each contribution while ensuring that the volume reads as a coherent argument rather than a loose anthology. The Introduction that follows this Preface sets out that argument in full, together with a chapter-by-chapter roadmap and the organizing questions that each chapter takes up; we will not repeat that material here.

This book is addressed to several overlapping audiences. We have written and edited it with graduate students and early-career researchers in mind, particularly those approaching food security from agricultural economics, development studies, or public policy, who are looking for a single volume that connects technical analysis to institutional theory. We have also kept policymakers and practitioners in view throughout, especially those working within the ministries, donor agencies, and civil society organizations that design and implement food security interventions in the countries discussed here. And we hope the volume will be useful to researchers already working in this field who are looking for comparative material beyond their own country or region of specialization.

No volume of this scope comes together without considerable debts. We are grateful to every contributor for the care they brought to their chapters, for their patience through multiple rounds of review, and for their willingness to engage seriously with the governance framing we asked them to adopt even when their own training inclined them toward more conventional production- or nutrition-centered analysis. We thank the peer reviewers who strengthened individual chapters with their comments, often substantially. We are grateful to our respective institutions, the Institute of Agricultural and Resource Economics at the University of Agriculture, Faisalabad, and the Department of Economics at Government College Women University,

Sialkot, for the time and support that made this project possible. And we thank our families for their patience during the long months of editorial work that a project of this kind inevitably demands.

Responsibility for the volume's remaining shortcomings rests with us as editors. Food security is too large and too consequential a subject for any single book to settle, and we do not claim to have settled it. What we hope this book offers instead is a sustained, comparative, and institutionally grounded case for rethinking how food security policy is designed, financed, and governed in the developing world, and a set of analytical tools that researchers and policymakers can carry forward into their own work. If the chapters that follow leave readers more attentive to the institutions standing between policy intention and food security outcome, the volume will have done what we set out for it to do.

Muhammad Khalid Bashir
Muhammad Umar Farrukh
Faisalabad and Sialkot, Pakistan, 2026

FOREWORD

Food insecurity in the twenty-first century is not principally a problem of insufficient production. Global cereal output has more than kept pace with population growth over the past three decades; calories, taken in aggregate, are not scarce. Yet hunger and chronic undernutrition persist concentrated in the same regions and often the same communities year after year, even in countries that have recorded genuine agricultural advances. This paradox, familiar to anyone working at the intersection of agricultural science and development policy, is the starting point for the volume you are about to read. It is a paradox that resists agronomic solutions alone. What is missing, repeatedly, is not yield potential or improved varieties, but the institutional capacity to translate productive gains into food security outcomes for those who need them most. *Rethinking Food Security Policy in Developing Countries* sets out, with rigor and comparative breadth, to explain why that gap persists and what can be done about it.

The volume's central argument that food insecurity in developing economies is best understood as a governance problem rather than a production shortfall is not a fashionable provocation; it is a conclusion supported by a substantial body of empirical and institutional work, including much of the research gathered in these pages. I have seen subsidy programs, designed with genuine technical sophistication, fail to reach the smallholders they were intended to serve because of capture along the distribution chain. I have seen decentralization reforms transfer responsibility to local governments without transferring the finance or capacity required to discharge it. And I have seen, far too often, water and land management decisions made without the institutional mechanisms needed to translate sound agronomic science into outcomes for the rural and urban poor who depend on them.

What distinguishes this volume from much of the food security literature is its refusal to treat institutional questions as a footnote to technical ones. The decision to give marine food systems: fisheries, aquaculture, and seaweed economies equal analytical standing alongside terrestrial agriculture is both overdue and, in my view, correct. For the hundreds of millions of people across coastal Asia and Africa for whom marine foods are a primary source of protein and income, a food security framework that omits the sea is incomplete by construction. Equally valuable is the volume's sustained attention to the political economy of reform: why inefficient subsidy and procurement arrangements persist even when their costs are well documented, and under what fiscal, institutional, and political conditions reform becomes politically feasible rather than merely economically desirable. These are not questions that crop scientists are always well placed to answer, which is precisely why a volume that brings economists, political scientists, and policy scholars together within a shared institutional framework is so valuable.

The South Asian dimension of this volume merits particular attention. Pakistan, Bangladesh, India, and their neighbors have each invested heavily in agricultural intensification, irrigation infrastructure, and food subsidy systems over the past half century. In doing so, they have accumulated a rich body of policy experience, both instructive successes and costly failures, from which the rest of the developing world can learn. The challenge of governing wheat procurement in environments of price volatility, the design of targeted social protection in the absence of comprehensive household data, and the politics of water pricing in smallholder irrigation systems are not unique to South Asia. However, the region has confronted them at a scale and over a time horizon that yields genuinely transferable policy lessons. The editors and contributors draw on that experience with precision, situating it within a comparative framework that spans Southeast Asia, sub-Saharan Africa, Latin America, and Europe. The result is a volume that is regionally grounded yet global in its implications.

This book will be of considerable value to the audiences I encounter most often: graduate students and early-career researchers in agricultural and development economics seeking a rigorous comparative treatment that connects technical analysis to institutional theory; and policymakers and practitioners in agriculture, finance, and social protection ministries who must translate strong evidence into politically feasible reform. The editors are to be commended for assembling a volume that is broad in scope yet disciplined around a coherent analytical thread. They have brought together contributors employing methods ranging from systematic review and time-series econometrics to political economy case analysis and primary survey research and have integrated these diverse approaches within a framework that ensures coherence without sacrificing depth.

Agricultural science has made remarkable strides over my career, and I remain convinced that innovation in crop physiology, genetics, and farming systems will continue to play a central role in feeding a growing and warming world. But science alone is not governance, and governance ultimately determines whether its benefits reach those who need them. I commend this volume to researchers, students, and policymakers who share the conviction that the most important frontier in global food security today lies not only in the laboratory or the field, but in the institutions that connect them to the table.

Kadambot H. M. Siddique
AM CitWA FTSE FNAAS FAAS FPAS
Hackett Professor and Director, The UWA Institute of Agriculture
The University of Western Australia, Perth, Australia

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[B L A N K P A G E]

CHAPTER 01

Introduction: Rethinking Food Security Policy in Developing Economies: Why Now, Why Differently?

Muhammad Khalid Bashir[1,2,*] & Muhammad Umar Farrukh[3]
[1]Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad, Pakistan
[2]Policy, Advocacy, and Outreach, Pak-Korea Nutrition Center, University of Agriculture, Faisalabad, Pakistan
[3]Department of Economics, Government College Women University, Sialkot, Pakistan
Corresponding author's email: khalid450@uaf.edu.pk

Abstract

This Introduction frames a twenty-three-chapter edited volume that asks why food insecurity persists in developing economies despite decades of sustained investment in agriculture, nutrition programs, and social protection. The chapters collectively argue that the root cause is not insufficient food production but a deficit of governance: weak institutions, misaligned political incentives, fragmented decentralization, regressive subsidy regimes, undervalued marine food systems, poorly managed market chains, and inadequate policy learning mechanisms. The Introduction articulates the volume's central argument, identifies the unifying analytical thread that runs across all chapters, situates the book in relation to existing literature, and poses twenty-one organizing questions, one drawn from each chapter, that the volume seeks to answer. A chapter roadmap guides the reader through the book's four-part structure: foundational context, institutional and political economy critique, case studies and domain-specific analyses, and forward-looking policy and governance frameworks.

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1. Central Argument

Food insecurity in developing economies is not fundamentally an agricultural production problem. It is a governance problem. This is the argument that animates every chapter of this volume, and it runs against the grain of a long tradition in food policy that has treated hunger as primarily a shortfall of supply, a gap to be filled by more seeds, more fertiliser, more irrigation, more yield. That tradition has achieved real things: the Green Revolution increased aggregate food production by orders of magnitude, and a small number of countries have since succeeded in escaping the worst forms of chronic hunger. But the gains have been unequal, ecologically costly, and institutionally brittle. More than 733 million people remained food insecure in 2023 (FAO *et al*., 2024). The overwhelming majority of them live in developing countries that have, in many cases, invested heavily in agriculture for decades.

The chapters in this book, contributed by scholars and researchers working across South Asia, Southeast Asia, sub-Saharan Africa, Latin America, and Europe, converge on a common diagnosis: the distance between food policy design and food security outcomes is explained by the quality, coherence, and accountability of institutions. Institutions determine whether subsidies reach farmers or are captured by intermediaries (Chapter 6). Institutions determine whether devolution produces responsive local food governance or merely displaces accountability without redistributing resources (Chapter 5). Institutions determine whether food price shocks are absorbed by well-designed safety nets or transferred as hunger to the urban poor (Chapter 8). Institutions determine whether fisheries and aquaculture are governed sustainably or depleted for short-term gain (Chapter 7). And institutions determine whether evidence actually changes policy, or whether policymakers continue with what is politically convenient regardless of what the data show (Chapter 16).

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The book does not argue that production is irrelevant. Climate-smart agriculture (Chapter 12), biofortification and precision farming (Chapter 3), sustainable aquaculture (Chapter 7), and agroforestry aligned with climate commitments (Chapter 18) all have productive roles to play. But it argues that no amount of agronomic innovation will translate into sustained food security unless the institutional environment within which that innovation is deployed is capable of delivering benefits to those who need them most, the rural poor, urban households spending more than half their income on food, smallholder farmers without market access or price information, and coastal communities whose food security depends on marine ecosystems that are increasingly stressed.

Rethinking food security policy, in the spirit of this volume, means rethinking the governance of food systems. It means taking institutions seriously not as a background condition but as the primary lever of change (North, 1990; Acemoglu & Robinson, 2012). It means recognising that food security is a political achievement, not merely an agricultural one, and that sustainable progress requires political strategy, institutional investment, and systematic learning from evidence, as much as it requires better seeds and more efficient supply chains.

2. One Organizing Question from Each Chapter

The twenty-two chapters of this volume address twenty-one interconnected questions. Together they constitute the intellectual architecture of the rethinking this book proposes. The questions are posed here, with the chapter that addresses each one.

Q1. ***(Chapter 2 (Akram et al.) Evolution of Food Security Policy)*** How have food security policies in developing economies evolved from production-centric post-independence approaches to more holistic frameworks, and what structural constraints, governance failures, political economy pressures, and institutional weaknesses, continue to limit their effectiveness across Asia and Africa?

Q2. ***(Chapter 3 (Sarfraz et al.) From Food Availability to Nutrition and Sustainable Food Systems)*** What are the pathways through which food systems must transition from a calorie-quantity focus to genuine nutrition security and environmental sustainability, and what role do innovations such as biofortification, precision agriculture, smart aquaculture, and circular economy principles play in that transition?

Q3. ***(Chapter 4 (Akhtar et al.) Institutional Failures and Reform Pathways)*** Why do food security institutions in developing economies, illustrated with particular depth in the case of Pakistan, persistently fail to reach the most vulnerable through design failures, coordination failures, accountability failures, and adaptive failures, and what multi-horizon reform pathways are politically feasible given prevailing elite capture and IMF conditionality?

Q4. ***(Chapter 5 (Razaq et al.) Decentralization and Local Food Governance)*** Under what conditions, matched finance, administrative capacity, accountability systems, and national minimum standards, does the decentralization of food governance authority genuinely strengthen food security outcomes, and what design principles distinguish effective devolution from the mere displacement of responsibility without resources?

Q5. ***(Chapter 6 (Wahab et al.) Political Economy of Subsidies, Procurement, and Price Controls)*** Why do economically inefficient and distributionally regressive food policy instruments, fertilizer subsidies, procurement monopolies, and retail price controls, persist across widely divergent country contexts from India and Egypt to Pakistan and Nigeria, and what political economy strategies make reform feasible without harming the poor during transition?

Q6. ***(Chapter 7 (Aslan et al.) Marine Food Security)*** How can marine food systems, fisheries, aquaculture, and seaweed farming, with evidence from Indonesia, India, and Tanzania, be better integrated into national food security policy frameworks, and how does the proposed Global Marine Food Security Index (GMFSI) fill the most consequential gap in existing food security assessment methodologies?

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Q7. ***(Chapter 8 (Rauf et al.) Food Price Volatility and Policy Responses)*** What are the primary drivers of food price volatility in developing economies, with particular attention to Pakistan's urban household welfare, and which policy interventions most effectively protect vulnerable populations without creating the market distortions, producer disincentives, and fiscal burdens that undermine long-run food system performance?

Q8. ***(Chapter 9 (Sadaf et al.), Trade Policy, Export Bans, and Import Dependence)*** How do export restrictions, import dependence, and asymmetric price transmission interact to shape food security outcomes across South Asian countries, India, Pakistan, Bangladesh, Sri Lanka, and Nepal, and what governance architectures and regional cooperation mechanisms can improve food system resilience without triggering beggar-thy-neighbor trade spirals?

Q9. ***(Chapter 10 (Sattar et al.) Market Integration and Value Chain Governance)*** How do physical infrastructure, market information systems, and quality standards, as structural pillars of value chain governance, jointly determine producer and consumer outcomes in developing economy food systems, and what integrated reform agenda can simultaneously reduce price spreads, raise smallholder participation, and lower consumer food costs?

Q10. ***(Chapter 11 (Islam et al.) Climate Shocks and Food System Vulnerability)*** Through which biophysical, socioeconomic, and institutional pathways do climate shocks, droughts, floods, heat stress, soil salinity, and cyclones, translate into food system vulnerability and nutritional deprivation, and what integrated, multi-level resilience strategies are most effective for smallholder farmers in marginal environments?

Q11. ***(Chapter 12 (Naqvi et al.) Adaptive Food Security Policies under Climate Uncertainty)*** How should food security governance frameworks be redesigned as adaptive rather than static systems, incorporating scenario planning, robust decision-making, early warning triggers, AI-assisted forecasting, and institutionalized feedback loops, to remain effective under the deep uncertainty that climate change imposes on agricultural planning?

Q12. ***(Chapter 13 (Kan et al.) Poverty, Inequality, and Food Access)*** How do structural inequalities, in assets, gender, space, and institutions, interact with poverty traps, external shocks, and global trade governance failures to reproduce food insecurity as a systemic outcome rather than a temporary shortfall, and what transformative policy frameworks address these root causes rather than their symptoms?

Q13. ***(Chapter 14 (Batool et al.) Food Security in Fragile and Conflict-Affected Contexts)*** Through what mechanisms do armed conflict, political fragility, economic instability, social marginalisation, and environmental vulnerability combine to destroy the four pillars of food security in the most difficult settings illustrated through Yemen, Syria, Sudan, and Gaza and what resilience strategies are viable when governance itself has failed?

Q14. ***(Chapter 15 (Ahmad et al.) Comparative Policy Lessons)*** What does systematic cross-country comparative analysis using the framework Food System Outcomes = f(Policy Mix × Institutions × Incentives × Resources × Climate × Capacity) reveal about which food security policies work, where they work, and under what institutional and contextual conditions, and what are the five key cross-cutting insights for policy design?

Q15. ***(Chapter 16 (Noor & Alam) Adaptive and Evidence-Based Policymaking)*** How can the IFPRI Kaleidoscope Model of policy change (Resnick *et al*., 2018), Swanson and Bhadwal's (2009) adaptive policymaking principles, and the taxonomy of single-, double-, and triple-loop organisational learning be applied to food security governance through the cases of Pakistan's Kissan Card, Brazil's CONSEA, China's policy experimentation, and Ethiopia's ATA to explain why some food security interventions endure and others collapse?

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Q16. ***(Chapter 17 (Author TBC) Digital Tools, Data Systems and AI)*** How are remote sensing, artificial intelligence, big data analytics, and predictive modelling transforming food security monitoring and policy design, what governance and ethical challenges like digital inequality, algorithmic bias, data sovereignty, and epistemic injustice must be addressed to ensure equitable outcomes, and what institutional frameworks are needed to translate technical capability into policy impact?

Q17. ***(Chapter 18 (Rashid et al.) Aligning Food Security with SDGs and Climate Commitments)*** How can developing economies align their national food security policies with the Sustainable Development Goals (particularly SDG 2 and SDG 13) and the Paris Agreement's climate commitments through climate-smart agriculture, agroforestry, sustainable land management, and policy coherence frameworks, while managing trade-offs between productivity, mitigation, and adaptation?

Q18. ***(Chapter 19 (Razaq et al.) National Food Security Transformation in South Asia)*** What do long-run time-series analyses of food security dynamics in Pakistan, India, and Bangladesh incorporating composite index construction, volatility modelling, ARDL cointegration, and structural break analysis reveal about the trends, vulnerabilities, and policy pathways for national food security transformation in South Asia?

Q19. ***(Chapter 20 (Shehzadi et al.) Food Waste among Young Consumers in Developing Countries)*** What economic, behavioural, attitudinal, institutional, and sociodemographic factors drive food waste among university students in developing countries with evidence from Pakistan and what combination of targeted institutional interventions, behavioural nudges, and policy reforms can most effectively reduce food destruction in educational settings while building a culture of sustainable consumption?

Q20. ***(Chapter 21 (Bashir and Gogi) Insects and Food Security in Developing Economies: Threat, Opportunity, and the Institutions That Decide Which Prevails)*** How do insects simultaneously undermine and offer pathways to strengthen food security in developing economies, and what institutional conditions determine which effect dominates in each country's context?

Q21. ***(Chapter 22 (Hafeez et al.) Comparative Policy Performance Across South Asia, Sub-Saharan Africa, and MENA)*** How do institutional structures, voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption, shape policy performance across South Asia, Sub-Saharan Africa, and MENA, and which policy innovations are transferable across these diverse governance contexts?

3. Gap in Literature: What Existing Books Miss

The scholarly literature on food security in developing economies is large, sophisticated, and growing. But it suffers from four structural gaps that this volume is specifically designed to address.

The first gap is the systematic underrepresentation of marine food systems. The overwhelming majority of food security scholarships and the vast majority of national food policy frameworks treat food security as a terrestrial phenomenon. Fisheries, aquaculture, and seaweed farming appear, when they appear at all, as specialist subsectors rather than as integral pillars of national food security. This is analytically unjustifiable: for hundreds of millions of people in coastal Indonesia, India, Tanzania, Bangladesh, and across the Pacific Island states and sub-Saharan African littoral, marine foods are the primary source of protein, micronutrients, and cash income. Chapter 8 of this volume directly addresses this gap by proposing the Global Marine Food Security Index (GMFSI) as an integrated assessment framework that treats marine food security on the same analytical footing as terrestrial food security.

The second gap is the disconnect between political economy analysis and comparative institutional analysis in food policy scholarship. We have a rich empirical literature on the effects of subsidies, export bans, public distribution systems, and procurement monopolies but relatively little systematic comparative work on why

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these instruments persists despite their documented inefficiencies, and what political conditions make reform feasible. Chapters 5 and 8 of this volume fill this gap with a four-pillar political economy framework (principal-agent theory, collective action problems, institutional path dependence, and distributional coalition theory) applied comparatively across India, Egypt, Pakistan, Indonesia, Nigeria, and Brazil.

The third gap is the treatment of decentralisation as a policy intervention rather than as a governance variable. A very large literature examines what decentralisation does to service delivery in health and education; a much smaller literature examines what it does to food security. The conditions under which subnational food governance is more effective than central direction and the design principles that distinguish functional devolution from merely displaced responsibility are poorly established. Chapter 4 of this volume develops a multilevel framework for local food governance and tests it against fiscal and institutional evidence from Pakistan, India, Brazil, Kenya, Indonesia, and Ethiopia.

The fourth gap is the absence of integration across the terrestrial-marine, production-governance, and national-international divides. Most food security volumes are either primarily agronomic or primarily political economy in their orientation; either production-focused or access-focused; either concerned with individual countries or with global aggregates. This volume is unusual in spanning all of these divides simultaneously, tracing the threads connecting smallholder price transmission and global agricultural trade governance, food waste behaviour in Pakistani universities and global food system sustainability, and adaptive governance theory and the everyday institutional realities of Pakistan's PASSCO wheat scandal.

4. How This Book Fills Those Gaps

This volume fills the four gaps identified above through three design choices.

First, it integrates marine and terrestrial food security analysis within a single edited volume, treating Chapter 8 not as an appendix or specialist contribution but as a foundational chapter that challenges readers working on terrestrial food systems to take marine food governance seriously. The GMFSI framework proposed there is a methodological contribution intended to stimulate further comparative research and, ultimately, to influence the food security assessment methodologies of international organisations including FAO, WFP, and IFPRI.

Second, it places institutional and political economy analysis at the centre of every chapter. Even chapters that might appear primarily technical on price transmission (Chapter 8), market integration (Chapter 9), digital tools (Chapter 17), or food waste (Chapter 20) are organized around the question of why dysfunctional arrangements persist and what governance conditions enable better outcomes. This institutional thread is the volume's analytical spine.

Third, it adopts a genuinely multi-scale perspective, connecting analysis at the household level (food waste behaviour, household welfare effects of price volatility), the community level (local food governance, smallholder market participation), the national level (institutional reform pathways, national food security transformation), the regional level (South Asian trade policy, comparative South Asian food security dynamics), and the global level (climate commitments, SDG alignment, marine food security). Food security outcomes are jointly produced across all of these scales simultaneously, and a volume that ignores any one of them will miss essential parts of the causal story.

5. Chapter Roadmap

The volume is organised into four thematic parts.

Part I: Foundational Context (Chapters 2–3)

Chapter 2 (Akram *et al*.) provides the historical and comparative foundation for the book's argument, tracing the evolution of food security policy in developing economies across three phases: the production-centric Green Revolution era (1950s–1970s), the access-and-distribution transition phase (1980s–1990s), and the current nutrition-sensitive and sustainability-oriented phase. Drawing on comparative evidence from Bangladesh, India, and Myanmar and case analyses of Pakistan and India, the chapter documents persistent

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governance constraints (institutional inefficiency, targeting failures, political economy distortions) that have limited policy effectiveness across all three phases. The key finding is that food security gains have been driven primarily by productivity improvement rather than structural changes in access and governance architecture.

Chapter 3 (Sarfraz *et al*.) examines the conceptual and practical shift from quantitative food availability to qualitative nutrition security and environmental sustainability. It surveys the determinants of food access and utilisation, documents the rising burden of both under-nutrition and diet-related non-communicable diseases, and explores the innovations (biofortification, precision agriculture, smart aquaculture, circular economy approaches in food systems) that offer pathways toward more nutritious and sustainable food futures. The chapter emphasises that technology alone cannot drive this transition; policy and governance must create enabling conditions for nutritional and environmental objectives to be embedded throughout food systems.

Part II: Institutional and Political Economy Critique (Chapters 4–6)

Chapter 4 (Akhtar *et al*.) is the analytical centrepiece of the book, developing a four-type typology of institutional failure design failure, coordination failure, accountability failure, and adaptive failure and applying it to the governance of food security in Pakistan. Drawing on comparative evidence from Bangladesh (nutritional progress through institutional innovation), India (Aadhaar-based PDS reform), Brazil (Fome Zero and CONSEA), and Ethiopia (Productive Safety Net Programme), the chapter argues that durable food security is an institutional accomplishment and outlines a multi-horizon reform pathway calibrated to Pakistan's political economy constraints.

Chapter 5 (Razaq *et al*.) examines decentralisation as a food security governance variable, developing a multilevel framework for local food governance and comparing fiscal and institutional patterns across Pakistan, India, Indonesia, Kenya, Brazil, Bangladesh, and Ethiopia using SNG-WOFI fiscal data. It identifies five risk mechanisms unfunded mandates, elite capture, territorial inequality, fragmentation, and exclusion and proposes seven design principles for effective decentralised food governance. The chapter argues that devolution is neither a cure nor a cause of failure by itself; it is a governance design problem that requires matched authority, finance, capacity, accountability, and national minimum standards.

Chapter 6 (Wahab *et al*.) builds a comprehensive political economy framework for explaining the persistence of economically inefficient food policy instruments such as fertilizer subsidies, procurement monopolies, and retail price controls across India, Egypt, Pakistan, Indonesia, Nigeria, and Brazil. Grounding the analysis in principal-agent theory, collective action problems, institutional path dependence, and distributional coalition theory, the chapter explains why reform is politically costly even when economically beneficial, and identifies the conditions like fiscal crisis, technocratic capacity, alternative social protection, and political leadership under which reform has succeeded. It concludes with a sequenced reform roadmap and ten policy recommendations.

Part III: Case Studies and Domain-Specific Analyses (Chapters 7–15)

Chapter 7 (Aslan *et al*.) addresses the volume's most consequential gap in existing food security literature: the systematic underrepresentation of marine food systems. Drawing on comparative evidence from Indonesia (the world's largest seaweed producer), India (the world's largest fishing employment base), and Tanzania (Africa's leading seaweed economy), the chapter proposes the Global Marine Food Security Index (GMFSI) a multidimensional framework integrating availability, accessibility, utilisation, and sustainability dimensions alongside a Seaweed Security Sub-Index as a novel analytical tool for assessing marine food security performance. Policy solutions spanning ecosystem-based fisheries management, sustainable aquaculture, seaweed integration into national nutrition programmes, and blue economy governance are evaluated.

Chapter 8 (Rauf *et al*.) provides a PRISMA-protocol systematic review of the drivers and consequences of food price volatility in developing economies, with particular attention to Pakistan. Drawing on household-level welfare studies using GARCH/IGARCH models and fixed-effect pseudo-panel approaches, the chapter

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documents the persistently negative effects of price instability on household welfare, dietary diversity, and nutrition outcomes for vulnerable urban populations. It evaluates trade policies, subsidies, price controls, and social safety nets as stabilisation instruments and concludes that no single instrument is adequate; an integrated policy framework combining market infrastructure development, social protection, and institutional strengthening is required.

Chapter 9 (Sadaf *et al*.) examines the complex relationship between trade policy instruments and food security outcomes in South Asia. Drawing on price transmission analysis (von Cramon-Taubadel, 1998), welfare economics, and comparative evidence on export bans and import dependence across India, Pakistan, Bangladesh, Sri Lanka, and Nepal, the chapter documents how export restrictions during the 2007–08 and subsequent food crises amplified rather than dampened price volatility for importing countries. It analyses the structural causes of South Asian import dependence and proposes strategic recommendations for regional food reserve mechanisms, rules-based export restriction frameworks, and diversified import sourcing strategies.

Chapter 10 (Sattar *et al*.) investigates market integration and value chain governance (Gereffi *et al*., 2005), deploying six econometric methods, Johansen cointegration, VECM, NARDL, OLS with fixed effects, Propensity Score Matching, and Heckman selection models, to demonstrate that road quality is the single strongest predictor of farm-gate prices ($\beta = 0.312$), that captive governance chains impose a 38% consumer welfare cost relative to competitive alternatives, and that full governance integration combining infrastructure, information, and inclusive standards raises smallholder market participation from 22% to 74%. The chapter argues for a coordinated five-pillar reform agenda: rural road investment, ICT-based market information systems, inclusive standards design, contract enforcement, and governance restructuring.

Chapter 11 (Islam *et al*.) maps the pathways through which climate shocks (drought, flooding, soil salinity, heat stress, and tropical cyclones) translate into food system vulnerability and nutritional deprivation. Drawing on the IAEA Technical Meeting framework and case evidence from the 2012–2016 California drought, Cyclone Amphan, Pakistan's 2022 floods, sub-Saharan African chronic drought systems, and South Asian heatwaves, the chapter documents the biophysical, socioeconomic, and gender dimensions of climate-food system interactions and identifies biotechnological innovations, climate-smart agriculture practices, and early warning systems as priority interventions.

Chapter 12 (Naqvi *et al*.) moves from the diagnosis of climate vulnerability to the design of adaptive policy responses. It argues that conventional static food security policies premised on stable climate and predictable supply-demand relationships are structurally inadequate under deep uncertainty. Drawing on adaptive governance theory, scenario-based planning, Robust Decision-Making (RDM; Lempert *et al*., 2019), trigger-based policy mechanisms, and AI-assisted forecasting, the chapter outlines how decision-making processes, learning systems, institutional agility, and specific policy tools (dynamic food reserves, flexible subsidies, climate-indexed insurance, scalable safety nets) must be redesigned for adaptive food security governance.

Chapter 13 (Kan *et al*.) analyses food insecurity as a structural outcome of multidimensional poverty, inequality, and external shocks rather than as a temporary shortfall. Drawing on Sen's (1981) entitlement approach, the Sustainable Livelihoods Framework, and distributional coalition theory, the chapter documents how asset inequality (particularly land), gender inequality, spatial inequality (rural-urban divide), institutional inequality (elite capture), and global trade governance failures interact to reproduce food insecurity across generations. The chapter proposes transformative political economy frameworks rights-based approaches, pro-poor land reform, gender-sensitive extension services, and restructured social protection as alternatives to the market-efficiency paradigm that has dominated food policy for four decades.

Chapter 14 (Batool *et al*.) examines food security in its most challenging context: fragile and conflict-affected states. Drawing on recent evidence from Sudan, Syria, Yemen, Gaza, and Lebanon (2022–2026), the chapter documents how armed conflict, political fragility, economic instability, social marginalisation, and environmental fragility jointly destroy each of the four pillars of food security (FAO, 2006). It develops a conceptual framework integrating conflict, market systems, and governance dynamics, reviews resilience strategies from diverse fragile contexts, and analyses the interplay between geopolitical wars and global food

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price crises including the Russian invasion of Ukraine's impact on wheat exports and the Middle East conflicts' effects on regional food access.

Chapter 15 (Ahmad *et al*.) synthesises evidence from cross-country comparative analysis using the framework Food System Outcomes = f(Policy Mix × Institutions × Incentives × Resources × Climate × Capacity). The chapter identifies five cross-cutting insights: that policy coherence is essential (fragmented initiatives produce contradictory incentives); that institutional capacity is the binding constraint on policy effectiveness; that political economy factors shape both policy design and uptake; that integrated approaches outperform sectoral interventions; and that adaptive learning is indispensable under uncertainty. It proposes a context typology linking policy appropriateness to institutional capacity levels and identifies the conditions for policy success drawing on experiences from Rwanda, Vietnam, Indonesia, Brazil, Ethiopia, Bangladesh, and India.

Part IV: Forward-Looking Policy and Governance Frameworks (Chapters 16–22)

Chapter 16 (Noor & Alam) provides the volume's most theoretically sophisticated analysis of food security governance reform, applying the IFPRI Kaleidoscope Model of policy change (Resnick *et al*., 2018), Swanson and Bhadwal's (2009) seven adaptive policymaking principles, and the taxonomy of single-, double-, and triple-loop organisational learning to four national case studies: Pakistan's Kissan Card Subsidy Programme, the institutionalisation and dismantling of Brazil's CONSEA, China's regional policy experimentation approach, and Ethiopia's Agricultural Transformation Agency (ATA). The chapter argues that policies achieving true durability are those anchored in institutions capable of sustained double and triple-loop learning, continuously questioning not just how policies are implemented but whether the right goals are being pursued and whether the learning mechanisms themselves are structured appropriately.

Chapter 17 (Author TBC) examines how remote sensing, artificial intelligence, big data analytics, and predictive modelling are transforming food security monitoring, early warning, and policy design. Drawing on sociotechnical systems theory, digital sovereignty frameworks, and evidence-to-policy translation models, the chapter documents both the transformative potential and the governance challenges of digital food security tools: a consistent digital divide concentrates technological benefits in high-income countries while the most food-insecure populations generate fewer of the digital signals these systems process; crop monitoring algorithms are frequently not available for independent review; and the majority of AI and remote sensing food security research is conducted by Global North institutions about Global South populations, constituting what the chapter terms 'epistemic injustice.'

Chapter 18 (Rashid *et al*.) maps the interfaces between food security, the SDGs (United Nations, 2015), and global climate commitments particularly SDG 2 (Zero Hunger), SDG 13 (Climate Action), and the Paris Agreement. It evaluates climate-smart agriculture, agroforestry, sustainable land and water management, and food loss and waste reduction as policy instruments that simultaneously advance food security and climate objectives. Drawing on evidence from Nationally Determined Contributions and National Adaptation Plans across developing economies, the chapter identifies institutional fragmentation as the primary barrier to SDG-climate alignment and argues that policy coherence across agriculture, trade, water, energy, and finance ministries is the critical enabling condition for achieving the synergies between food security and climate action that individual sectoral policies cannot produce alone.

Chapter 19 (Razaq *et al*.) provides the most technically sophisticated empirical analysis in the volume, constructing a six-dimensional National Food Security Index for Pakistan, India, and Bangladesh using time-series data from 2000 to 2025. Drawing on ARDL cointegration, NARDL asymmetry analysis, VAR/VECM models, GARCH volatility modelling, and structural break analysis, the chapter documents the trends, volatility patterns, and structural shifts in South Asian food security over a quarter century including the impacts of the 2007–08 global food price crisis, COVID-19, and the Ukraine war and derives policy pathways calibrated to each country's specific institutional and resource context.

Chapter 20 (Shehzadi *et al*.) continues with an analysis of food waste among young consumers in developing countries, focusing on university students in Pakistan. Drawing on the economic theory of consumer

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behaviour, the Theory of Planned Behaviour (TPB; Ajzen, 1991), institutional theory, and behavioural economics, the chapter documents the drivers of plate waste in institutional dining settings portion sizes, subsidised pricing, attitudinal factors, social norms, and structural institutional practices and evaluates the effectiveness of trayless dining programmes, mindfulness campaigns, portion control initiatives, and waste auditing systems. The chapter is a reminder that food security is not only about getting food to people who lack it; it is also about not wasting the food that reaches people who have it.

Chapter 21 (Bashir and Gogi) turns to a domain that food security scholarship has generally treated as peripheral: insects. Drawing on the desert locust upsurge of 2019–2021, the spread of fall armyworm across Asia and Africa, and the slow institutionalization of insect farming and entomophagy in countries such as Thailand, the chapter develops the Insect-Mediated Food Security Framework (IMFSF), modelling net food security impact as the difference between institutionally mediated losses avoided and value captured. Applied to Pakistan, the framework shows how weak extension delivery, pesticide subsidy distortions, fragmented quarantine authority, and an absent regulatory pathway for insect-based food and feed constrain both sides of the ledger, and the chapter closes with governance recommendations on surveillance, integrated pest management, and regulatory reform.

Chapter 22 (Hafeez *et al*.) closes the volume with a comparative analysis of policy performance across South Asia, Sub-Saharan Africa, and MENA. Drawing on Institutional Theory and the Worldwide Governance Indicators framework, the chapter evaluates six governance dimensions, voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption, to show that policy success depends on institutional capacity and local adaptation as much as design. It finds that South Asia benefits from democratic participation and digital transformation, Sub-Saharan Africa innovates despite institutional constraints, and MENA leverages centralized planning, concluding that effective policy transfer requires institutional compatibility and context-specific adaptation rather than a single universal model.

References

Acemoglu, D., & Robinson, J. A. (2012). Why nations fail: The origins of power, prosperity, and poverty. Crown Publishers.

Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

FAO. (2006). Food security (Policy Brief No. 2). Food and Agriculture Organization of the United Nations.

FAO, IFAD, UNICEF, WFP, & WHO. (2024). The state of food security and nutrition in the world 2024. Food and Agriculture Organization of the United Nations.

Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). The governance of global value chains. Review of International Political Economy, 12(1), 78–104. https://doi.org/10.1080/09692290500049805

Lempert, R. J., Popper, S. W., & Bankes, S. C. (2019). Decision making under deep uncertainty. Annual Review of Environment and Resources, 44, 13–36.

North, D. C. (1990). Institutions, institutional change, and economic performance. Cambridge University Press.

Resnick, D., Haggblade, S., Babu, S., Hendriks, S. L., & Mather, D. (2018). The Kaleidoscope Model of policy change: Applications to food security policy in Zambia. World Development, 109, 101–120.

Sen, A. (1981). Poverty and famines: An essay on entitlement and deprivation. Oxford University Press.

Swanson, D. A., & Bhadwal, S. (Eds.). (2009). Creating adaptive policies: A guide for policy-making in an uncertain world. IDRC/Sage.

United Nations. (2015). Transforming our world: The 2030 Agenda for Sustainable Development.

von Cramon-Taubadel, S. (1998). Estimating asymmetric price transmission with the error correction representation. European Review of Agricultural Economics, 25(1), 1–18. https://doi.org/10.1093/erae/25.1.1

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CHAPTER 2

Evolution of Food Security Policy in Developing Economies

Ramsha Akram[1], Seerat Saleem[2,*], Afsheen Aqeel[3], Sabir Hussain[4], Kiran Aslam[5], Qaiser Ali Sultan[6], Umar Farooq[1] & Nida Firdous[1]
[1]Department of Food Science and Technology, Muhammad Nawaz Sharef University of Agriculture, Multan
[2]Human Nutrition and Food Technology, Faculty of Allied Health Sciences, Superior University, Lahore
[3]Department of Microbiology, University of Karachi
[4]Department of Human Nutrition and Dietetics, Muhammad Nawaz Shareef University of Agriculture, Multan
[5]Department of Nutritional Sciences, Govt Graduate College of Home Economics, Faisalabad
[6]Pakistan Standards and Quality Control Authority, Peshawar, KPK, Pakistan
Corresponding author's email: seeratrao79@gmail.com

Abstract:

This chapter focuses on food security policies in emerging countries, with consideration of the changes in food security policies from production-focused policies to holistic approaches. The policies regarding food security in the initial years after gaining their independence were concerned with improving food production by adopting Green Revolution technology. While such policies succeeded in bringing about self-sufficiency and improved food security, they had some limitations, including regional disparity, natural resource disparities, and environmental degradation. In the transitional period of food security policy development (1980s and 1990s), emphasis shifted to policies that ensured food accessibility. Measures such as food subsidies and poverty alleviation schemes were implemented to ensure that vulnerable groups had access to affordable food items. This period has seen an evolution of food security policies to include nutrition and sustainable approaches. Despite all these developments, there still exist some constraints like poor governance, bureaucratic inefficiency, political economy considerations, and inadequate information, which hamper the effectiveness of policies designed to deal with food insecurity. In conclusion of the chapter, it is made clear that sustainable food security cannot be achieved unless an integrated policy strategy is adopted.

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1. Introduction

Food is a basic need of a human being, but the problem of sufficient, safe, and nutritious access to food is one of the most acute worldwide issues. This is a major problem especially in the developing economies where high population growth, chronic poverty as well as structural inequalities remain barriers to access to food. Although a significant economic development in most low- and middle-income nations, food insecurity is pervasive with over two billion people in the world, most of whom reside in these areas. These circumstances underscore the structural aspect of food insecurity and its close links with income limitation and resource lack (FAO et al., 2019). Food insecurity is a multidimensional phenomenon that is not limited to food availability. It is not only affected by the socio-economic status of individuals and households, but also by the larger structural issues of economic growth patterns, income inequality, and the capacity of institutions. The relationship between macroeconomic performance and individual well-being is multifaceted, as in most developing economies, economic growth has failed to translate into equitable access to food. This paradox has led to a growing academic interest in the quest to get to know the underlying causes of food insecurity (Holleman & Conti, 2020). There is an emerging literature that highlights the importance of macroeconomic factors in influencing the outcome of food security, but empirical evidence is inconclusive. As an example, other studies indicate that there is no significant correlation between economic growth and declines in child undernutrition, whereas others indicate only minor positive food security outcomes. The cross-country analysis indicates that determinants of food insecurity differ according to the

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economic development levels, and education, employment, social capital, and household income are some of the determinants that have a significant role to play. These results imply that economic growth on its own cannot help mitigating food insecurity unless it is accompanied by underlying socio-economic inequalities (Subramanyam et al., 2011; Harttgen et al., 2013; Smith et al., 2017a; Smith et al., 2017b).

Recent studies have been paying more attention to the role of income inequality and national income levels in determining the outcome of food security. There is evidence that although an increase in GDP per capita is usually found to be linked to a decrease in food insecurity, the association is much weaker in high-income inequality countries. In this case, the unequal distribution of income inhibits the capacity of vulnerable populations to enjoy the fruits of economic growth, and in this regard, it limits the enhancement of food access. This highlights the need to incorporate equity issues in food security policy frameworks (Holleman & Conti, 2020). The issue of food security is also highly relevant to the process of economic development and social stability. The availability of appropriate quantities of food results in good health, higher productivity and quality human resource development. On the contrary, the problem of food insecurity results in malnutrition, lack of productivity, poverty and ultimately social unrest. There have been examples where food scarcity and rising food prices have even caused political instability, which demonstrates the significance of food security in promoting economic and social stability (Manap & Ismail, 2019).

The concept of food security has evolved significantly over the years. Food production increase and food self-sufficiency at the national level were the initial objectives in the post-World War II government actions. The focus then expanded from food production to food distribution and availability problems, particularly since the entitlement strategy was introduced, which emphasized the importance of income on food availability. Given rising concerns over climate change and environmental degradation, as well as the vulnerability of the international food supply chain, the concept has evolved further to encompass resilience, sustainability, and nutrition (Akbari et al., 2022). The chapter aims to answer the following research question: How have food security policies developed in developing economies and what policy lessons can be learned for more resilient, inclusive and sustainable food systems? To answer this question, the chapter reviews the historical development of food security policies, discusses key policy shifts, contrasts regional experiences in Asia, Africa and Latin America, and summarizes the implications for future policy design.

2. Theoretical perspectives on food security policy evolution

The evolution of food security policy in developing economies is best understood through several complementary theoretical perspectives. These frameworks illustrate how policy priorities have shifted from a narrow focus on agricultural production to encompassing broader concerns such as food access**,** nutrition, sustainability, governance, and **r**esilience. Grasping these theoretical foundations is crucial for interpreting the historical transformation of food security policies and assessing their effectiveness**s**.

2.1 Modernization theory and the production-centered paradigm

Early food security policies in developing countries were largely shaped by modernization theory, which emphasized economic growth and technological advancement as the main drivers of development. Within this framework, increasing agricultural productivity was seen as the most effective way to reduce hunger and poverty. This perspective strongly influenced the Green Revolution of the 1960s and 1970s, which promoted the adoption of high-yielding crop varieties, irrigation systems**,** chemical fertilizers, and mechanization (Evenson & Gollin, 2003). The Green Revolution significantly boosted food grain production in many developing countries, notably India and Mexico. However, critics argue that while production rose, the benefits were unevenly distributed, often favoring large landowners with better access to resources and credit. Additionally, intensive agricultural practices led to environmental degradation, including soil nutrient depletion and groundwater overexploitation (Patel, 2013; Ladha et al., 2003). These challenges underscored the need to move beyond a purely production-oriented view of food security.

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2.2 Entitlement theory and food access

A major shift in food security thinking emerged with Sen's Entitlement Theory, which challenged the assumption that hunger is solely caused by inadequate food production. Sen (1981) argued that famines and food insecurity often occur despite sufficient food availability because individuals lack the economic, social, or legal means to access food. This perspective shifted policy focus toward poverty reduction, income generation, employment programs, food subsidies, and social protection measures. As a result, many developing countries expanded public distribution systems, cash transfer programs, and targeted food assistance initiatives. The growing recognition of food access as a critical dimension of food security played a significant role in shaping the multidimensional definition adopted by the Food and Agriculture Organization (FAO).

2.3 Rights-based approaches to food security

The rights-based approach to food security gained prominence after the international recognition of the right to adequate food as a fundamental human right. The FAO Voluntary Guidelines (2004) encouraged governments to embed food security within national legal and policy frameworks, emphasizing accountability, participation, non-discrimination, and access to food as a legal entitlement rather than a welfare provision (FAO, 2004). This approach stresses government accountability, legal guarantees, and social justice in food security policies. A notable example is India's National Food Security Act (NFSA) of 2013, which legally guarantees subsidized food access to a large segment of the population. Proponents argue that rights-based policies enhance social protection and reduce vulnerability, though concerns about fiscal sustainability and implementation effectiveness persist (George & McKay, 2019).

2.4 Food sovereignty and political ecology perspectives

The food sovereignty perspective emerged as a critique of globalization and market-oriented agricultural policies. Advocates argue that communities and nations should have the right to define their own food systems, prioritize local production, and protect smallholder farmers from unequal global market forces (Patel, 2009). Similarly, political ecology focuses on the role of power relations, governance structures, and economic inequalities in shaping food security outcomes. From this view, food insecurity is not just a technical or production issue but also results from unequal access to resources, land ownership patterns, trade arrangements, and political decision-making processes (Clapp, 2014). These perspectives are crucial for understanding why similar food security policies often produce different outcomes across regions.

2.5 Resilience theory and sustainable food systems

Recent food security research increasingly incorporates resilience theory and sustainable food systems approaches. Resilience refers to the capacity of food systems to absorb shocks and adapt to disturbances such as climate change, economic crises, pandemics, and geopolitical disruptions (Tendall et al., 2015). The sustainable food systems perspective broadens the food security agenda beyond availability and access to include environmental sustainability, nutrition, resource conservation, and long-term system stability. This approach aligns closely with Sustainable Development Goal 2 (Zero Hunger), which emphasizes not only ending hunger but also promoting sustainable agriculture and resilient food systems (United Nations, 2015).

3. Methodology (Narrative Review Approach Aligned with AI-Driven Food Security)

This study adopts a narrative literature review methodology to synthesize interdisciplinary and evolving research on food security policy and the integration of artificial intelligence (AI) into food systems. Narrative reviews are particularly appropriate for conceptual integration and thematic interpretation rather than statistical aggregation, allowing critical examination of policy evolution, governance structures, and technological transformation (Grant & Booth, 2009). Given the increasing application of AI in agriculture and food security, this approach facilitates the integration of evidence from agriculture, policy studies, sustainability science, and data science into a coherent analytical framework.

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The literature was collected from reputable academic and institutional sources, including Google Scholar, Scopus, Web of Science, PubMed, FAO, WHO, World Bank databases, United Nations SDG reports, and OECD food security reports. Grey literature, such as policy briefs, technical reports, and AI-agriculture white papers, was also included to capture emerging developments in digital food systems and governance. Using multiple sources enabled triangulation of evidence across scientific, policy, and technological domains (FAO, 2021).

A structured keyword search strategy was employed using combinations of terms such as *food security policy evolution*, *AI in agriculture and food systems*, *precision agriculture and machine learning*, *climate change and food security governance*, *digital transformation of agriculture*, *sustainable food systems and artificial intelligence*, and *early warning systems and food insecurity*. Boolean operators (AND, OR) refined the searches and ensured retrieval of relevant interdisciplinary studies. AI-related keywords were intentionally incorporated to reflect the growing role of digital technologies in food security policy and agricultural transformation (Liakos et al., 2018; Klerkx et al., 2019).

The review included peer-reviewed journal articles and reports published by FAO, WHO, the United Nations, and the World Bank that addressed food security policy, governance, sustainability, AI, machine learning, and digital agriculture. Only English-language publications were considered. Studies unrelated to food systems or policy, clinical nutrition research lacking system-level implications, duplicate records, and non-peer-reviewed sources without policy or AI relevance were excluded to maintain analytical rigor and policy relevance.

The review covers literature published between 2000 and 2025, encompassing major transitions from the post-Millennium Development Goals (MDGs) era to the Sustainable Development Goals (SDGs), alongside developments in climate-resilient agriculture and AI-enabled food systems. Foundational works published before 2000, including Sen's entitlement theory, were selectively incorporated because of their enduring theoretical significance (Sen, 1981). This timeframe also captures the rapid digitalization of agriculture and the emergence of AI-based analytics for food systems (Wolfert et al., 2017).

A thematic synthesis approach was used to identify recurring patterns and conceptual relationships across literature. Five interrelated themes guided the analysis: (i) the evolution of food security policy frameworks, (ii) governance and institutional mechanisms, (iii) climate change and resilience in food systems, (iv) nutrition-sensitive food security approaches, and (v) digital technologies and AI-driven innovation in agriculture. This thematic framework links traditional food security theories with contemporary digital approaches and provides a basis for understanding policy evolution in developing countries.

Building on this synthesis, the chapter proposes a four-stage analytical framework encompassing production-centric approaches, access-and-distribution transitions, nutrition-sensitive and rights-based frameworks, and contemporary sustainable, digitally enabled food systems. Comparative analysis across Asia, Africa, and Latin America demonstrates that governance quality and institutional capacity largely determine policy outcomes. This supports recent evidence showing that implementation gaps, rather than policy design alone, are the primary determinants of food security performance across 120 countries between 2000 and 2022 (Mumah et al., 2025). The framework therefore reconceptualizes food security challenges as institutional and political economy issues rather than merely technical policy failures.

4. Conceptual Foundations of Food Security

When everyone has physical, social, and financial access to enough safe, nourishing food that satisfies their dietary needs and food choices for an active and healthy life, it's food security. In 2002, the 1996 definition was expanded to include the term "Social." According to WFP, hunger is "a condition that exists when all people, at all times, are free from hunger" (WFP, 2009). We will refer to the original WFS definition even if WFP utilizes a definition that appears to be much simpler because it contains many crucial components for the analysis.

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4.1 The Four Dimensions of Food Security

Food security is built upon four interrelated dimensions i.e. availability, access, utilization, and stability, derived from the definition adopted by the World Food Summit (WFS). Together, these dimensions provide a comprehensive framework for assessing food security at household, community, national, and global levels.

Availability refers to the physical presence of sufficient food through domestic production, imports, food stocks, and food aid. The World Food Program (WFP) defines food availability as "the amount of food that is present in a country or area through all forms of domestic production, imports, food stocks, and food aid" (WFP, 2009). Historically, food security was equated with food availability despite recognition by the FAO that poverty is the primary cause of hunger and malnutrition (Shaw, 2007). This production-oriented perspective encouraged policies focused on increasing agricultural output. Although global agricultural production has consistently outpaced population growth over the past five decades, food insecurity persists because adequate food supplies do not guarantee that all people can obtain food. Consequently, availability is necessary but not sufficient to ensure food security.

Access is the second dimension and refers to having physical, economic, and social access to food. Inspired by Sen's entitlement approach, food access extends beyond production to include the ability of individuals and households to obtain adequate food. The WFP defines access as "a household's ability to acquire an adequate amount of food regularly through a combination of purchases, barter, borrowings, food assistance or gifts" (WFP, 2009). Food access comprises three components. Physical access depends on transportation infrastructure, market connectivity, and information systems that ensure food reaches consumers. Economic access relates to households' purchasing power and affordability, an issue that gained prominence following the 2005 Niger food crisis and the 2008 global food price crisis. Increasingly, researchers recognize that hunger often results from unaffordable food rather than insufficient production. Market systems therefore play a crucial role in food security, as "most people, especially the poor, rely on market systems to provide food and essential goods and services" (Simon, 2012). The third component, social or socio-cultural access, recognizes that gender, cultural norms, and social exclusion may limit access even when food is physically available and affordable. Although research in this area remains limited, existing studies highlight the importance of addressing social inequalities in food security policies (Simon, 2012).

Figure 2.1: The four components of food system with their major elements

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Utilization represents the third dimension and emphasizes the consumption of safe and nutritious food that meets dietary requirements. The WFS definition highlights that food must not only be available and accessible but also be effectively utilized through appropriate dietary choices, preparation, storage, and nutrient absorption. Health care, sanitation, clean water, and food safety are integral to this dimension. Evidence shows that malnutrition can persist even where food is abundant because of poor dietary practices or inadequate utilization (Conte & Morrow, 2002). Consequently, nutrition education, food safety, and public health interventions are essential components of food security. Growing research also emphasizes the close relationship between food security and food safety, although conceptual confusion persists in some languages where both concepts share the same terminology (Simon, 2012).

Stability is the fourth dimension and refers to maintaining availability, access, and utilization always. Food security must be sustained over time rather than achieved temporarily. Stability distinguishes between chronic food insecurity, characterized by persistent inability to meet food needs, and transitory food insecurity caused by short-term shocks such as economic crises, conflicts, natural disasters, or seasonal fluctuations. Seasonality represents a common form of cyclical food insecurity that particularly affects vulnerable populations (Simon, 2012). Together, these four dimensions provide a holistic framework for understanding food security and designing effective policies that address both immediate needs and long-term resilience.

5. Historical Evolution of Food Security Policies

5.1 Early Phase: Production-Centric Policies (1950s–1970s)

Focus on Increasing Agricultural Output

The initial stage of food security policies mainly focused on the need to boost agricultural output to solve food shortages in the newly independent states. In India, the government had initiated programs like the Grow More Food Campaign, Community Development Programs, and Agricultural Technical Assistance Programs with investments made in irrigation, fertilizers, research, and rural infrastructure. The purpose of these interventions was to enhance domestic production systems and increase food supply, alongside changing the types of crops to suit various ecological conditions (Balaguru, 2013; Bjornlund & Bjornlund, 2025). These production-oriented policies led to a huge increase in agricultural production. India experienced about 7 per cent growth in food production in the initial five-year plan (1951 1956), and the increase in irrigation rose to 20 per cent of the cropped area between 1950 and 1960. Moreover, there was a 20-30 percent increase in yields of a variety of crops, such as barley, tobacco, jute, chickpeas, tea, and cotton, which proved the efficiency of policies aimed at improving yields (Patel, 2013; Bjornlund & Bjornlund, 2025).

Role of the Green Revolution

The Green Revolution further supported production-oriented approaches by introducing high-yield seeds, chemicals, irrigation, and mechanization. In Mexico, the significant investments made for the construction of irrigation infrastructure, where more than 55% of investments came from public funds, contributed towards the expansion of irrigated land and the adoption of intensive cultivation methods like double cropping. Credit facilities, subsidies, and the provision of agricultural input also aided in boosting agricultural intensification and production (Evenson & Gollin, 2002; Bjornlund & Bjornlund, 2025). Therefore, there was a rapid increase in agricultural output in those regions that could benefit from these innovations. For instance, in northern Mexico, the number of cultivated areas increased from 2.2 million hectares in 1940 to 4.3 million hectares in 1960, while there was consistent improvement in the output of crops such as wheat and cotton. The favorable price of the products offered by the government compared to the international market price of up to 33% facilitated exports (Bjornlund & Bjornlund, 2025).

Production-Centric Nature of Policies

The Green Revolution method was fundamentally concerned with production and therefore made investments only in high potential areas and commercial farmers. This meant that islands of agricultural development were created with access to irrigation, credit, and infrastructure, while others, especially those

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that practiced rain-fed agriculture, were marginalized. This kind of development model was because the Green Revolution had a limited scope as far as production was concerned and failed to distribute agricultural resources equally to all regions and people (Matchett, 2006; Patel, 2013; Bjornlund & Bjornlund, 2025). In many developing countries, the policy of agriculture had its primary focus on producing goods for export and supplying cheap staple foods to urban populations. In most cases, governments were in control of production and prices and utilized external sources such as food aid and loans (Bjornlund & Bjornlund, 2025).

Limitations of the Production-Centric Approach

Notwithstanding the increased production levels, production-oriented agriculture had its fair share of problems, such as inequality. The main beneficiaries of the Green Revolution included large and commercial farmers who, through the process of consolidation, evicted small-scale farmers from their lands. This resulted in a polarized agricultural sector where there were few rich farmers and many poor or landless rural households (Patel, 2013; Bjornlund & Bjornlund, 2025). In addition, since less diverse crops were being grown but with higher yields, the agricultural diversity was lost, and hence, traditional food systems were neglected. Initiatives directed towards improving agricultural production did not consider the indigenous crops and farming practices that are used locally to build resilient food systems (Matchett, 2006; Bjornlund & Bjornlund, 2025). Lastly, environmental degradation was an issue associated with production-oriented agriculture. This included the heavy usage of chemicals in the form of fertilizers, monoculture planting of crops, and indiscriminate exploitation of water resources. These factors culminated in low agricultural yields due to depleted soil and water quality (Ladha et al., 2003; Ray et al., 2012; Bhattacharyya et al., 2015; Bjornlund & Bjornlund, 2025).

Overall Assessment

In all, the initial stages of the food security policy were successful in ensuring higher food production levels but did not consider other aspects of food security. The focus on the production of food was partly responsible for the development of regional imbalances, problems in environmental conservation, and over-reliance on other markets. This shows that even though production plays an important role, it alone cannot guarantee food security (Giller, 2020; Bjornlund & Bjornlund, 2025).

Table 2.1: Agricultural Growth and Structural Outcomes under Production-Centric Policies and the Green Revolution (1950s–1970s)

Indicator	Country/Region	Time Period	Change/Value	Implication
Food output growth	India	1951–1956	~7% per annum	Significant increase in agricultural production
Irrigated area	India	1950–1960	7% → 20% of cropped area	Expansion of irrigation infrastructure
Crop yield increase	India	Late 1960s	20–30% increase	Improved productivity due to policy support
Harvested land	Mexico	1940–1960	2.2 → 4.3 million hectares	Expansion of cultivated land
Irrigated land	Mexico	Green Revolution period	+50% increase	Intensification of agriculture
Export crop production	Mexico	1950s–1960s	+85% increase (wheat & cotton)	Growth of export-oriented agriculture
Credit & investment distribution	Mexico	Green Revolution period	Majority to commercial farms	Unequal access to resources
Fertilizer & input access	Mexico	Green Revolution period	Controlled & targeted	Favored large-scale producers

Source: Bjornlund & Bjornlund, 2025

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5.2 Transition Phase: Access and Distribution (1980s–1990s)

Emergence of Poverty Alleviation and Food Subsidy Programs

In the period between the 1980s and 1990s, food security policies experienced an important change from production-oriented policies to those concerned with the improvement of accessibility to food. This change came about after acknowledging the fact that increased food supplies at the national level may not always lead to food security within households because of poverty, lack of employment opportunities, and income disparity. Therefore, poverty reduction became an integral part of food security policy approaches (Giller, 2020; FAO, 2019). In consequence, the governments developed food subsidies and other policies with the aim of reducing the cost of accessing food products. Such policies include subsidizing food supplies, income assistance policies, and programs concerned with the nutritional requirements of people (Devereux et al., 2020; Clapp, 2020).

Public Distribution Systems and Safety Nets

This was when Public Distribution Systems (PDS) and safety nets were made key aspects of food security policies. The government created systems that were able to deliver basic foodstuff like cereals to poor groups at affordable prices. This move was intended to help control the level of food intake by ensuring the effects of poverty were alleviated, especially among impoverished communities (George & McKay, 2019). Furthermore, food safety nets such as cash transfer projects and nutrition support measures were initiated to improve food security in poor communities. Such safety nets provided a cushion against temporary food insecurity but also contributed significantly to alleviating poverty in the long term. Despite the success, there were numerous challenges related to inefficiencies, leakage, and budgetary constraints associated with the implementation of these measures (Devereux et al., 2020; FAO, 2021).

5.3 Modern Phase: Nutrition-Sensitive and Sustainable Policies (2000s–Present)

Issues that the nutrition-sensitive agriculture approach aims to solve include:

(i) Raising the level of agricultural production is so that more food becomes available and accessible to all people.
(ii) Ensuring that the food produced is diverse and sustainable through environmentally friendly practices such as conservation agriculture, irrigation, and integrated pest management (IPM).
(iii) Nutritional enrichment through fortification so that micronutrient deficiencies are eliminated due to increased micronutrient density in the products (Hossain & Simi, 2024).\

6. Food Security Policies: Instruments and Implementation Mechanisms

Developing economies have food security policies that are executed using various policy instruments to deal with availability, access, and utilization. Although these instruments have been transformed greatly, they are not effective enough because of structural, institutional, and political limitations. Critical analysis of these policies shows that, even though these interventions have achieved significant success, most of them have design and implementation issues, which restrict their effectiveness in the long run.

6.1 Food Subsidies and Price Control Mechanisms

Price controls and food subsidies are common to make food more affordable and cushion the vulnerable groups against market uncertainty. The interventions are effective in boosting consumption in the short term and stabilizing prices. India, particularly the National Food Security Act, illustrates how price-based subsidies can contribute to providing the most food to low-income families dramatically (Debnath et al., 2018). However, it is important to note that subsidy schemes are likely to result in market inefficiencies and budget obligations, and they are not sustainable in the long run. Universal or poorly targeted subsidies can result in leakages and inclusion errors, in which benefits do not end up with the most vulnerable groups. Additionally, price controls may deter the involvement of the private sector and motivate producers, which may have an impact on long-term supply (FAO, 2021; Pinstrup-Andersen, 2009). Thus, although subsidies

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are needed to provide direct access to food, the design of subsidies should be enhanced by making them more targeted and aligned with social protection systems in general.

6.2 Agricultural Support Programs

The agricultural support programs are very important in boosting food supply through boosting productivity and assisting farmers. Such interventions have been especially effective in areas where the institutions are well-established, which led to higher crop yield and incomes in rural areas (World Bank, 2022). Nevertheless, globalization has transformed the way agricultural production is carried out, with systems encouraging export-based systems that are not necessarily sustainable. More importantly, these systems have resulted in monoculture, the destruction of the environment, and a higher reliance on chemical inputs, especially in developing nations (Robinson, 2018; Jorgenson & Kuykendall, 2008). Moreover, export crops may compromise domestic food security because the focus on export crops may result in the diversion of resources to the production of staple food. These issues underscore one major shortcoming of agricultural support policies; that they tend to focus on productivity rather than sustainability and equity. The design of effective policies should therefore be balanced in terms of productivity, environmental protection, and inclusive development (Lencucha et al., 2020).

6.3 Social Safety Nets and Nutrition Interventions

Nutrition interventions and social safety nets play a crucial role in resolving the problem of food access and food use, especially among vulnerable groups. The cash transfer and feeding at schools' interventions have shown tremendous success in improving food consumption and diversification (FAO, 2021). Most importantly, however, is the problem of sustainability and efficiency in the allocation of resources for these programs, as well as the risks of creating dependency on such aid. Safety nets in some cases can simply be a temporary remedy and fail to address underlying problems of food insecurity, such as unemployment and low agricultural productivity. Poorly coordinated implementation of these policies may limit their effectiveness (Ruel & Alderman, 2013). Such interventions must be linked to broader development initiatives, such as employment generation and agriculture reforms, to ensure their sustainability.

6.4 Public Distribution Systems (PDS)

Public Distribution Systems play an important role in ensuring food security policy in nations like India, where subsidized food is provided to millions of families. These are crucial for reducing hunger and stabilizing consumption (George & McKay, 2019). Nonetheless, PDS is normally faulted for inefficiency, corruption, and poor administrative control, including leakage and errors in exclusion. This leads to reduced efficiency of the process and increases the cost of implementation. Further, the centralized distribution system may lack flexibility to cater to regional demand and food preferences. Therefore, reforms will target areas of digitalization, decentralization, and improved targeting strategies.

6.5 Public–Private Partnerships (PPPs)

The potential for change in food systems through public-private partnerships is vast since the private sector operates in an efficient and innovative way. It enables investment in infrastructure, value chain, and technology, which results in higher productivity and less post-harvest loss (IFAD, 2020). However, PPPs also create significant issues of equity and governance. Unless there is proper regulation, the participation of the private sector can be determined by profit motives at the expense of social goals, which can exclude smallholder farmers. Inequality may also be enhanced by power imbalances between the state institutions and the business corporations. Thus, it is important to have proper governance structures so that PPPs can lead to inclusive and sustainable food security (World Bank, 2022; FAO, 2021).

6.6 Case Study Spotlight: Pakistan

Pakistan provides an important case for examining the evolution of food security policies in developing economies, given its strong dependence on agriculture, high vulnerability to climate change, and ongoing policy reforms. Over time, the country's food security approach has shifted from a narrow focus on

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production to a more comprehensive framework that incorporates access, nutrition, and sustainability. In earlier phases, Pakistan placed significant emphasis on agricultural production support policies, including input subsidies, expansion of irrigation systems, and price support mechanisms for key crops such as wheat and rice. These measures contributed to increased agricultural output and helped ensure national food availability. However, despite these gains in production, food insecurity continues to persist, largely due to unequal access, widespread poverty, and regional disparities (Mughal & Fontan Sers, 2020).

In recent years, there has been a noticeable transition toward a more integrated policy framework, particularly with the introduction of the National Food Security Policy (2018). This policy aims to strengthen food availability, improve access, enhance nutritional outcomes, and promote sustainability. It also places considerable emphasis on climate-resilient agriculture and institutional reforms to address emerging challenges such as population growth and environmental pressures (Parveen et al., 2023). Despite these advancements, several critical gaps remain. Weak governance structures limited institutional capacity, and shortcomings in implementation continue to constrain policy effectiveness. Empirical studies indicate that poverty, exposure to climate-related shocks, and limited market access significantly influence household food security, especially in rural areas (Khan et al., 2025). Moreover, inefficiencies in subsidy programs and the absence of well-targeted safety nets further reduce the overall impact of policy interventions. Overall, the case of Pakistan illustrates that while food security policies have evolved considerably, persistent challenges related to implementation, governance, and inclusiveness remain. This experience highlights the importance of adopting integrated and well-coordinated policies that combine agricultural development with social protection measures and institutional strengthening.

6.7 Case Study Spotlight: India

India represents one of the most comprehensive and well-established food security frameworks among developing economies. The country's approach has evolved considerably from a production-oriented strategy during the Green Revolution to a rights-based framework with the introduction of the National Food Security Act (NFSA), 2013, which legally guarantees access to subsidized food grains for nearly two-thirds of the population (Government of India, 2013). This transition reflects a broader shift in policy thinking—from a primary focus on food availability to a more inclusive approach that emphasizes food access and social protection. A key component of India's food security system is the Public Distribution System (PDS), which provides essential food commodities such as rice and wheat at subsidized prices. This system has played a significant role in reducing hunger and ensuring stable food consumption among low-income households. In addition, India has implemented several complementary nutrition-oriented interventions, including the Mid-Day Meal Scheme and the Integrated Child Development Services (ICDS), which aim to address malnutrition and improve dietary outcomes, particularly among children and women (Ruel & Alderman, 2013; FAO, 2021).

Despite its extensive coverage and strong institutional foundation, India's food security system continues to face many challenges. Research highlights concerns related to inefficiencies, leakage, corruption, and the substantial fiscal burden associated with large-scale subsidy programs (Petrikova, 2019). Moreover, questions have been raised about the sustainability of procurement and price support policies, especially considering environmental pressures and resource limitations (Kishore et al., 2025). These issues point to the need for better targeting, improved governance, and greater efficiency in policy implementation. Overall, India's experience shows that while large-scale public interventions can significantly improve food access, their long-term success depends on strong institutional capacity, transparency, and fiscal sustainability. The Indian case offers important lessons for other developing economies, particularly in achieving a balance between wide coverage and efficient, accountable delivery systems.

7. Comparative Analysis of Food Security Policies in Developing Economies

Food security can be defined as a condition where all people are assured of continuous availability of adequate, safe, and nutritious food that is sufficient in meeting their nutritional requirements and preferences for leading a healthy lifestyle. Following the food crisis in 2008, food security became a high-profile issue

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for consideration in several countries, such as Bangladesh, India, and Myanmar. With a large population of each country, together forming 21% of the world's population and consuming 32% and 39% of the world's rice and pulse production, food security has become a top priority for them since their independence. China proposed the Bangladesh-China-India-Myanmar Economic Corridor initiative in 2013 for promoting economic cooperation between these countries. Agricultural cooperation may be considered among other areas of cooperation under these initiatives. For such a purpose, a study is needed regarding food security and the main determinants of food security in these countries (Chen & Lu, 2018).

Around 1990, Bangladesh, India, and Myanmar also launched economic reforms that helped them liberalize their food economy and international trade, leading to an increase in the domestic production of food commodities (Del Ninno et al., 2007; Kurosaki, 2008). Self-sufficiency in rice has been attained in Bangladesh because of the fast growth of rice production due to sustained rice growth since the 1970s (Bell et al., 2015; Fiedler, 2014; Ganesh-Kumar et al., 2012). The growth in cereal production in India is more than 70% between 1980 and 2007 (Dev & Sharma, 2010), while the growth in rice, pulses, and maize production in Myanmar since 1988 has been very encouraging (Haggblade et al., 2014). Other than economic reforms and proper policies, there has been the adoption of improved agricultural inputs and land use that have contributed significantly to the growth of grain production (Chen & Lu, 2018). A comparative analysis of the food security situation in the developing countries can be used to provide empirical evidence on the relationships between production and consumption. The Food Security Index (FSI) is based on the proportion of domestic production to consumption and serves as an indicator of food security in any given nation. The table below and chart illustrate the trend and causes of food security in Bangladesh, India, and Myanmar from 1990 to 2013 (Chen & Lu, 2018).

Table 2.2 Food Security Index and Contributing Factors (1990–2013)

Country	FSI (1990)	FSI (2013)	Production Growth (%)	Consumption Growth (%)	Main Production Driver	Main Consumption Driver
Bangladesh	0.88	1.02	92.55%	66.6%	Crop Yield (≈88%)	Population Growth
India	1.01	1.09	52.68%	39.89%	Crop Yield (≈98%)	Population Growth
Myanmar	1.06	1.09	165.73%	158.11%	Land Expansion (≈81%)	Per Capita Consumption

From the results obtained from the comparative analysis, food security gains achieved in developing nations have been achieved mainly through improvement in agricultural productivity instead of the extent of cultivation of arable land. For example, for India and Bangladesh, there was almost 98% and 88%, respectively, contribution to production increase from yield increase. Nevertheless, the population increase has led to higher demand for food.

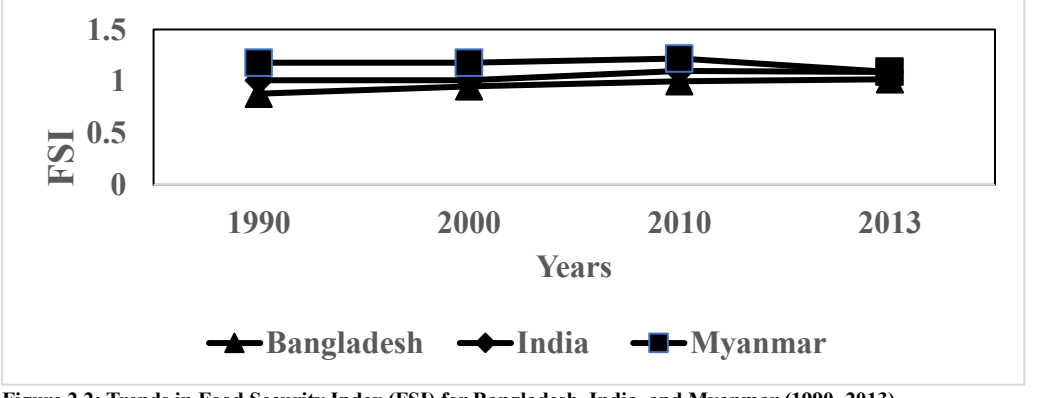

Figure 2.2: Trends in Food Security Index (FSI) for Bangladesh, India, and Myanmar (1990–2013)

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On the other hand, for Myanmar, food production increase was mainly due to the extent of cultivated arable land, while per capita food increase was responsible for demand increase (Chen & Lu, 2018).The developing countries in Asia and Africa continuously experience problems related to food security as a large portion of the undernourished global population resides in such countries. The concept of food security has been extensively reviewed based on three basic dimensions, which include food availability, food access, and food use. The comparative meta-review by these researchers indicates that despite similarities between policies implemented in both regions, their results vary greatly owing to the differences in the quality of institutions and economic development in the two continents. It is worth noting that 88% of the undernourished people live in Asia and Africa (Bashir & Schilizzi, 2013).

Comparative evidence demonstrates that food security outcomes vary considerably across regions because of differences in governance, institutional capacity, agricultural investment, and policy design. While Asia, Africa, and Latin America have all implemented food security strategies, their priorities and levels of success differ substantially.

In terms of **food availability**, many Asian countries have achieved stronger outcomes through productivity-oriented policies supported by substantial public investment in irrigation, high-yield seed varieties, agricultural research, and rural infrastructure. These interventions have significantly increased agricultural productivity and strengthened domestic food supplies. African countries have also prioritized agricultural production and increased public investment in the sector; however, productivity gains have generally been constrained by weaker infrastructure, institutional limitations, and climate vulnerability (Bashir & Schilizzi, 2013; World Bank, 2022).

Regarding **food access**, Asian countries have complemented production policies with public distribution systems, agricultural subsidies, and cash transfer programs that enhance purchasing power and reduce poverty. Such integrated approaches have expanded food access across socioeconomic groups. In contrast, many African countries have relied more heavily on food aid and international assistance to address recurrent food shortages. Although humanitarian assistance provides essential short-term relief, it does not offer a sustainable long-term solution to structural food insecurity (Bashir & Schilizzi, 2013; FAO, 2021). With respect to **food utilization**, several Asian countries have increasingly incorporated nutrition-sensitive interventions that improve dietary quality and health outcomes. In many African countries, however, food security policies continue to emphasize production while giving comparatively less attention to nutrition, food safety, and health, contributing to persistent malnutrition despite improvements in agricultural output (Bashir & Schilizzi, 2013; FAO, 2021).

Nevertheless, Asia's stronger performance should not be interpreted as evidence of universally superior institutions. Policy effectiveness depends on a combination of governance quality, political commitment, agricultural investment, social protection systems, and country-specific socioeconomic conditions. Moreover, considerable variation exists within both Asia and Africa, indicating that institutional capacity alone cannot fully explain food security outcomes (World Bank, 2022).

Within Asia, countries such as India and China illustrate the importance of active state involvement in food security. India has strengthened food access through its Public Distribution System (PDS), while China has pursued food self-sufficiency through coordinated agricultural policies and strategic planning. Although these interventions have improved food security, challenges remain, including implementation inefficiencies, food losses, and fiscal pressures (Smith, 2013).

In Africa, food security policies have been shaped by political instability, weak governance, dependence on rain-fed agriculture, and high exposure to climate-related shocks such as droughts and floods. Governments have emphasized emergency food assistance, agricultural development, and resilience-building; however, inadequate infrastructure, poor market connectivity, institutional weaknesses, and armed conflicts continue to undermine policy effectiveness (Smith, 2013; FAO, 2021).

Latin America presents a different policy model by placing greater emphasis on poverty reduction and social protection. Conditional cash transfer (CCT) programs, including Brazil's *Bolsa Família* and Mexico's

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Prospera, have linked financial assistance to education and healthcare participation, improving household food access, reducing poverty, and strengthening human capital. These policies have contributed significantly to regional food security improvements (Smith, 2013; World Bank, 2022).

Overall, cross-regional comparisons indicate that no single policy model guarantees food security. Rather, successful outcomes emerge from the interaction of sound governance, institutional capacity, sustained agricultural investment, effective social protection, and context-specific policy implementation. Asian experiences highlight the importance of combining productivity growth with social protection, African experiences underscore the need for stronger institutions and resilience, while Latin America demonstrates the value of inclusive social welfare programs. These lessons suggest that integrated, context-sensitive policies are more effective than reliance on any single intervention (Clapp, 2020; FAO et al., 2023; World Bank, 2022).

8. Role of International Organizations in Food Security

8.1 Contributions of FAO, World Bank, and IFAD

The international organizations play a critical part in the provision of solutions to food security problems faced in developing countries by means of offering financial aid and technical expertise in addition to policy advice. The primary mandate of FAO in tackling food insecurity lies in its efforts towards global leadership in the field of food security where it gathers information, develops standards, and helps nations to formulate appropriate agriculture and nutrition policies. Additionally, it provides technical and professional knowledge about how to boost the level of agriculture production sustainably. On the other hand, the role of the World Bank lies in offering financing of agriculture and rural development projects as well as implementing infrastructural development projects aimed at poverty reduction. Lastly, IFAD's main role involves helping smallholder farmers alleviate rural poverty and improve their access to agriculture products markets (FAO, 2021). IFAD complements these efforts by investing in rural development, improving smallholder farmers' access to finance and markets, and supporting inclusive agricultural growth. These interventions contribute to poverty reduction and strengthen food security, particularly in regions where agriculture remains the primary source of livelihood (IFAD, 2020). In summary, all these entities are involved in the governance of food security from various angles such as availability, accessibility, and consumption of food sources.

8.2 Global Initiatives (e.g., SDGs, Zero Hunger)

The efforts by international organizations have played a vital role in shaping the policies of food security for nations and regions. For instance, the SDGs by the UN included Goal 2 that was aimed at "Zero Hunger." It is designed in such a way as to end all forms of hunger, attain food security, improve nutrition, and ensure sustainable agriculture before 2030. Examples of the programs under SDGs include the Zero Hunger Challenge. The emphasis here is on the integration approach such as improving production efficiencies, minimizing food waste, and improving nutrition outcomes. These programs have led to many countries aligning their policies with those at the global levels as a way of promoting international collaboration (United Nations, 2015). Moreover, international organizations like CFS and various global nutrition initiatives are instrumental in making the policies more coherent and accountable through international cooperation. Such programs encourage countries to integrate their policies with global goals, leading to better monitoring and evaluation measures. Countries adopting the SDGs framework show improved results when it comes to ending hunger and malnutrition (FAO, 2021; von Braun et al., 2021).

8.3 Influence of International Funding and Policy Guidance

The role played by international financing is vital in ensuring that developing nations have sufficient means to implement their food security initiatives. With the financing provided by international institutions such as the World Bank and IFAD, developing countries can invest in agriculture, rural development, and research. Such investments enable the improvement of production efficiency, climate change resiliency, and food distribution mechanisms. In addition, international agencies offer technical guidance on how to develop national food security policies. The problem that might be encountered in using international financing includes the dependency issue and the lack of national policy autonomy. Research studies reveal that

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international funding might result in dependency due to a divergence between the priorities of donors and the needs of recipient nations. Nonetheless, international funding is necessary to address some structural challenges that include poverty, volatility in food prices, and climatic risk (World Bank, 2022; FAO, 2021). International policy guidance also ensures that decision-makers adopt evidence-based policymaking (Bashir & Schilizzi, 2013). While international organizations have bolstered food security policy through financial support and technical assistance, successful implementation ultimately depends on domestic institutional capacity. The following section discusses the principal challenges affecting policy implementation in developing economies.

9. Challenges in Food Security Policy Implementation

9.1 Governance and Institutional Limitations

However, the implementation of food security policies is hampered by poor governance and institutional weaknesses, especially in developing nations. The study notes that most of the sub-Saharan countries continue to rely heavily on the export of agricultural produce without any value addition to the commodity, exposing such countries to vagaries in the global market environment and undermining the efforts at implementing such policies successfully. Such reliance has undermined their efforts at achieving food sovereignty (Dietz, 2018; Giller, 2020; Bjornlund & Bjornlund, 2025). Also, shortcomings within institutions for implementing agricultural policies, such as the absence of coordination, poor support services, and inadequate regulation, have impeded the effectiveness of the Green Revolution approaches in areas like Africa. The failure to establish effective institutions to assist small-scale farmers and ensure market regulation has led to agricultural policies that prioritize commercial agriculture (Bjornlund & Bjornlund, 2025).

9.2 Inefficiencies in Targeting and Distribution

It is evident that inefficiencies occur in the allocation of resources towards agricultural subsidies and inputs. According to the study presented, it shows that subsidy schemes are unable to reach their target audiences, especially for the small-scale farmer. In Nigeria for instance, only 11% of the subsidized fertilizers went to the farmers, whereas the remainder was sold to middlemen at a price (Asante & Mullard, 2021; Bjornlund & Bjornlund, 2025). In addition, the operations of the distribution system can also be hampered by market distortions and opportunistic behaviors. Agro-dealers and middlemen capitalize on the weaknesses in regulations to monopolize supply and pricing to sell their products at higher costs while requiring farmers to sell at lower prices (Ragasa et al., 2018; Bjornlund & Bjornlund, 2025).

9.3 Political Economy Constraints

Political economy plays a crucial role in shaping food security policy implementation. The paper notes that the Green Revolution and later agricultural policies were formulated through the interests of the Global North and multinational companies, which led to unfair trade practices and market systems at the expense of developing countries (Magdoff, 2013; Bjornlund & Bjornlund, 2025). Furthermore, the liberalization of financial institutions and regulations resulted in more speculative activities within agricultural markets and price volatility, thereby reducing the capability of governments to regulate food prices. This posed serious effects on food security, especially during times of global food crisis, whereby price increases would adversely affect the poor and provoke civil unrest in several countries (Collier & Rohner, 2008; Bjornlund & Bjornlund, 2025).

9.4 Data Gaps and Monitoring Issues

The article indirectly shows issues surrounding data and monitoring due to the ineffectiveness of policy evaluation and accountability in implementation processes. As stated in the article, in Africa, there was the implementation of subsidies on fertilizers, which was done without proper monitoring measures in place, resulting in issues such as rent-seeking behavior, corruption, and even smuggling of the input across the borders. Lack of proper mechanisms for monitoring meant there was difficulty in following how the fertilizer was used by the targeted individuals (Asante & Mullard, 2021; Bjornlund & Bjornlund, 2025). In addition,

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lack of relevant data on how the farmer had fared made it difficult for policymakers to come up with appropriate measures that would address food insecurity especially amongst small farmers (Ragasa et al., 2018; Bjornlund & Bjornlund, 2025).

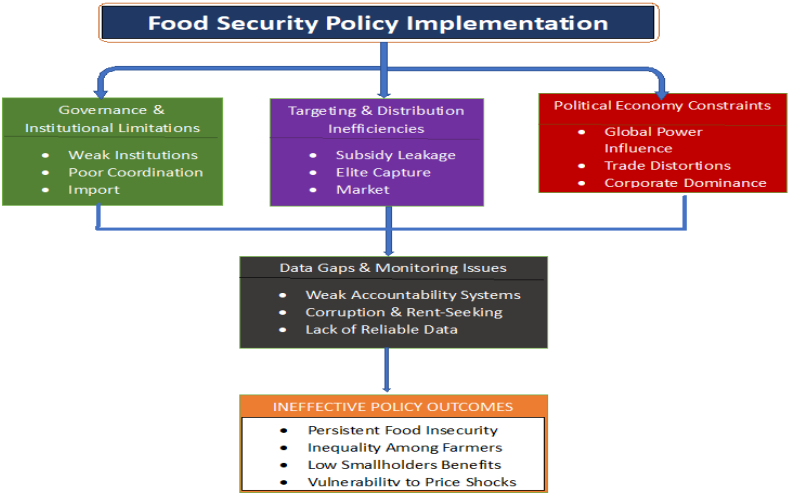

Figure 2.3: Conceptual Framework of Challenges in Food Security Policy Implementation

Table 2.3: Challenges in Food Security Policy Implementation and Supporting Evidence

Challenges	Key issues identified	Evidence from the paper	References
Governance and Institutional Limitations	Institutional incapacity, reliance on international markets, and inadequate policy coordination	The economy of Sub-Saharan Africa continues to rely on the export of basic products without much value added, leaving it vulnerable to any external shock and undermining its food security	Dietz (2018); Giller (2020); Bjornlund & Bjornlund (2025)
Inefficiencies in Targeting and Distribution	Ineffective subsidy distribution, diversion by middlemen, and uneven fertilizer distribution	Just 11% of the subsidized fertilizers got to the farmers in Nigeria, most being absorbed by the intermediaries who sold the fertilizers at the market prices	Asante & Mullard (2021); Bjornlund & Bjornlund (2025)
	Distorted markets and exploitative marketing mechanisms	Prices were manipulated in favor of agro-dealers who compelled farmers to sell their produce at low prices but retained high retail prices	Ragasa et al. (2018); Bjornlund & Bjornlund (2025)
Political Economy Constraints	Role of global powers and corporations; Imbalance in trade relations	The policies for agricultural development and Green Revolution were formulated keeping in view the interest of Global North, restricting balanced development in Global South	Bjornlund & Bjornlund (2025)
	Volatility in prices and limited government control	Due to deregulation and speculation, food prices became more volatile, making prices go up while cutting farmers' profits	Magdoff (2013); Collier & Rohner (2008); Bjornlund & Bjornlund (2025)
Data Gaps and Monitoring Issues	Corruption and poor monitoring systems	Fertilizers subsidy programs were carried out without any monitoring, resulting in corruption, favoritism, and smuggling of fertilizers	Asante & Mullard (2021); Bjornlund & Bjornlund (2025)
	Data inadequacy for policy formulation	Lack of monitoring and evaluation made it impossible to develop sound policies based on empirical evidence	Ragasa et al. (2018); Bjornlund & Bjornlund (2025)

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The conceptual framework demonstrates the interconnected difficulties associated with the implementation of policies aimed at improving food security. Poor governance and institutions, together with inefficiencies related to the targeting and delivery processes, make the structure of policy implementation weak. This is additionally complicated by problems with political economy, such as those associated with global market forces and corporatism. In addition to this, information deficiencies and poor monitoring make it difficult to ensure effectiveness due to a lack of transparency and accountability (Figure 1.3).

10. Future Directions for Food Security Policy

Future policies are likely to focus on building sustainable, resilient, and inclusive food systems. According to recent research, there is a need to incorporate climate-smart agriculture and sustainable environmental practices to solve problems such as climate change and depletion of natural resources (Bodirsky et al., 2020; Galanakis, 2024). A shift from food security towards nutrition security is anticipated as future policies aim to tackle issues of poor nutrition and unhealthy diets. As a result, future policies will have to be nutrition-sensitive to ensure good health (Adhikari et al., 2023; Thorndike et al., 2022). Finally, future policies are likely to adopt digital technology to improve the efficiency of agricultural productivity and governance. Other themes of future food security policies include effective governance and institutions, inclusive development, especially for vulnerable communities, and tackling the challenges posed by urban environments and changing consumption patterns (Ikudayisi & Adejumo, 2025).

11. Conclusion

Food security policies in developing countries have evolved from production-centered approaches to comprehensive frameworks that recognize food security as a multidimensional concept encompassing food availability, access, utilization, sustainability, and effective institutions. This evolution demonstrates that increasing agricultural production alone is insufficient to eliminate hunger unless accompanied by measures that address poverty, inequality, nutrition, governance, and institutional capacity. While earlier policies succeeded in boosting food production, they were less effective in achieving sustainable food security because they overlooked the socioeconomic and institutional factors that determine equitable access to food.

These findings have important implications for policymakers seeking to achieve Sustainable Development Goal 2 (Zero Hunger). Future food security strategies should adopt integrated policy frameworks that extend beyond increasing agricultural output to include improved food access, nutrition, environmental sustainability, and institutional effectiveness (United Nations, 2015). As climate change increasingly threatens agricultural productivity and food systems, greater investment is required in climate-smart agriculture, climate-resilient crop varieties, sustainable water resource management, and disaster risk reduction to strengthen resilience and ensure long-term food security (FAO et al., 2021). At the same time, the rapid advancement of digital technologies presents significant opportunities to improve agricultural productivity, optimize resource use, strengthen market integration, and enhance evidence-based decision-making through digital agriculture and artificial intelligence (Wolfert et al., 2017; Galanakis, 2024). These technological innovations, however, must be supported by effective governance reforms, including stronger institutions, transparent policy implementation, inter-agency coordination, and robust monitoring and evaluation mechanisms to maximize their impact.

Looking ahead, further research is needed to examine how emerging global challenges, including climate change, digital transformation, and geopolitical developments, affect the effectiveness of food security policies in developing countries. Comparative studies evaluating governance systems, institutional arrangements, and policy instruments across different regions would provide valuable insights into designing more effective interventions for achieving SDG 2. Future research should also investigate how digital technologies, institutional reforms, and climate adaptation strategies can be integrated to build resilient, inclusive, and sustainable food systems capable of responding to evolving environmental and socioeconomic challenges.

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References:

Adhikari, N., Adhikari, M., Shrestha, N., Pradhananga, P., Poudel, B., Dhungel, S., & Shrestha, A. (2023). Nutrition and food security in Nepal: a narrative review of policies. *Nutrition Reviews*, *81*(12), 1612-1625. https://doi.org/10.1093/nutrit/nuad025

Akbari, M., Foroudi, P., Shahmoradi, M., Padash, H., Parizi, Z. S., Khosravani, A., ... & Cuomo, M. T. (2022). The evolution of food security: where are we now, where should we go next? *Sustainability*, *14*(6), 3634. https://doi.org/10.3390/su14063634.

Asante, K. T., & Mullard, S. (2021). Social accountability and anti-corruption in Ghana's Fertiliser Subsidy Programme. *Chr. Michelsen Institute*. https://www.researchgate.net/profile/Kofi-Asante-3/publication/355675455_Social_accountability_and_anti-_corruption_in_Ghana's_Fertiliser_Subsidy_Programme/links/61794f3aa767a03c14bd14b6/Social-accountability-and-anti-corruption-in-Ghanas-Fertiliser-Subsidy-Programme.pdf

Balaguru, T. (2013). National agricultural research system in India: history, vision, mandate, organization and functions. *Reading material of Foundation course for Agricultural Research Scientists, NAARM, Hyderabad, India*. https://aiasa.org.in/wp-content/uploads/2015/07/NARS-India.pdf(open in a new window)

Bashir, M. K., & Schilizzi, S. (2013). Food security policy analysis in developing countries: A comparative study of Asia and Africa. *Journal of the Science of Food and Agriculture*, 93(10), 2400–2407.

Bell, A. R., Bryan, E., Ringler, C., & Ahmed, A. (2015). Rice productivity in Bangladesh: What are the benefits of irrigation? *Land use policy*, *48*, 1-12. https://doi.org/10.1016/j.landusepol.2015.05.019

Bhattacharyya, R., Ghosh, B. N., Mishra, P. K., Mandal, B., Rao, C. S., Sarkar, D., & Franzluebbers, A. J. (2015). Soil degradation in India: Challenges and potential solutions. *Sustainability*, *7*(4), 3528-3570. https://doi.org/10.3390/su7043528

Bjornlund, V., & Bjornlund, H. (2025). *Reviewing the Green Revolution strategy in view of lessons from Mexico and India – Africa*. International Journal of Water Resources Development, 41(2), 229–273. https://doi.org/10.1080/07900627.2024.2363954

Bodirsky, B. L., Dietrich, J. P., Martinelli, E., Stenstad, A., Pradhan, P., Gabrysch, S., ... & Popp, A. (2020). The ongoing nutrition transition thwarts long-term targets for food security, public health and environmental protection. *Scientific reports*, *10*(1), 19778. https://doi.org/10.1038/s41598-020-75213-3

Chen, Y., & Lu, C. (2018). A comparative analysis on food security in Bangladesh, India and Myanmar. *Sustainability*, *10*(2), 405. https://doi.org/10.3390/su10020405

Clapp, J. (2014). Food security and food sovereignty: Getting past the binary. *Dialogues in Human Geography*, *4*(2), 206-211. https://doi.org/10.1177/2043820614537159

Clapp, J. (2020). Food security and nutrition: building a global narrative towards 2030. https://openknowledge.fao.org/handle/20.500.14283/ca9759en

Collier, P., & Rohner, D. (2008). Democracy, development, and conflict. *Journal of the European Economic Association*, *6*(2-3), 531-540. https://ora.ox.ac.uk/objects/uuid:03e553bf-c33a-433a-8168-64eb57f2abaa/files/m0ac99328ba623ea83d90160f0af672f1

Conte, A., & Morrow, N. (2002). Mali: Rural community and household food security profiles. Vulnerability Analysis and Mapping. *Rome: World Food Programme*. https://www.jstor.org/stable/resrep00556.11

Debnath, D., Babu, S., Ghosh, P., & Helmar, M. (2018). The impact of India's food security policy on domestic and international rice market. *Journal of Policy Modeling*, *40*(2), 265-283. https://www.sciencedirect.com/science/article/pii/S0161893817300984

Del Ninno, C., Dorosh, P. A., & Subbarao, K. (2007). Food aid, domestic policy and food security: Contrasting experiences from South Asia and sub-Saharan Africa. *Food policy*, *32*(4), 413-435. https://doi.org/10.1016/j.foodpol.2006.11.007

Dev, S. M., & Sharma, A. N. (2010). Food security in India: Performance, challenges and policies. https://www.oxfamindia.org/sites/default/files/VII. Food Security in India-Performance, Challenges and Policies.pdf

Devereux, S., Béné, C., & Hoddinott, J. (2020). Conceptualising COVID-19's impacts on household food security: Devereux S. et al. *Food security*, *12*(4), 769-772. https://doi.org/10.1007/s12571-020-01085-0

Dietz, T. (2018). Online representation of sustainable city initiatives in Africa: how inclusive? *International Development Policy| Revue internationale de politique de développement*, (10), 139-161. https://doi.org/10.4000/poldev.2674

Evenson, R. E., & Gollin, D. (2003). Assessing the impact of the Green Revolution, 1960 to 2000. *science*, *300*(5620), 758-762. https://doi.org/10.1126/science.1078710

Evenson, R., & Gollin, D. (2002). The Green Revolution: An end of century perspective. https://core.ac.uk/download/pdf/6315369.pdf(open in a new window)

© 2026 The Authors. Published under CC BY 4.0. | https://doi.org/10.66529/book.9786277945039.2026.ch2

FAO, IFAD, UNICEF, WFP, and WHO. 2023. *The State of Food Security and Nutrition in the World 2023. Urbanization, agrifood systems transformation, and healthy diets across the rural–urban continuum*. Rome, FAO. https://doi.org/10.4060/cc3017en available at: https://openknowledge.fao.org/handle/20.500.14283/cc3017en

FAO. (2019). The State of Food Security and Nutrition in the World 2019. Safeguarding against economic slowdowns and downturns. Rome, FAO. (Assessed on 31-03-2026 at 10:11). https://openknowledge.fao.org/server/api/core/bitstreams/16480532-17e9-4b61-b388-1d6d86414470/content

FAO. (2021). The State of Food Security and Nutrition in the World 2021. Transforming food systems for food security, improved nutrition and affordable healthy diets for all. Rome, FAO. (Assessed on 31-03-2026 at 10:11). https://openknowledge.fao.org/server/api/core/bitstreams/1c38676f-f5f7-47cf-81b3-f4c9794eba8a/content

Fiedler, J. L. (2014). Food Crop Production, Nutrient Availability, and Nutrient Intakes in Bangladesh: Exploring the Agriculture Nutrition Nexus with the 2010 Household Income and Expenditure Survey. *Food and nutrition bulletin*, *35*(4), 487-508. https://doi.org/10.1177/156482651403500410

Food and Agriculture Organization of the United Nations. (2004). *Voluntary guidelines to support the progressive realization of the right to adequate food in the context of national food security*. FAO. Available at: https://www.fao.org/4/y7937e/y7937e00.htm

Galanakis, C. M. (2024). The future of food. *Foods*, *13*(4), 506. https://doi.org/10.3390/foods13040506

Ganesh-Kumar, A., Prasad, S. K., & Pullabhotla, H. (2012). Supply and demand for cereals in Bangladesh: 2010–2030. https://hdl.handle.net/10568/153883

George, N. A., & McKay, F. H. (2019). The public distribution system and food security in India. *International journal of environmental research and public health*, *16*(17), 3221. https://doi.org/10.3390/ijerph16173221

Giller, K. E. (2020). The food security conundrum of sub-Saharan Africa. *Global Food Security*, *26*, 100431. https://doi.org/10.1016/j.gfs.2020.100431

Government of India. (2013). *National Food Security Act, 2013*. Ministry of Law and Justice. Available at: https://www.indiacode.nic.in Assessed on 05-04-2026 at 9:50 A.M.

Grant, M. J., & Booth, A. (2009). A typology of reviews: an analysis of 14 review types and associated methodologies. *Health information & libraries journal*, *26*(2), 91-108. https://doi.org/10.1111/j.1471-1842.2009.00848.x

Haggblade, S., Boughton, D., Cho, K. M., Denning, G., Kloeppinger-Todd, R., Oo, Z., ... & Wong, L. C. (2014). Strategic choices shaping agricultural performance and food security in Myanmar. *Journal of International Affairs*, 55-71. https://www.jstor.org/stable/24461735

Harttgen, K., Klasen, S., & Vollmer, S. (2013). Economic growth and child undernutrition in sub-Saharan Africa. *Population and development review*, *39*(3), 397-412. https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1728-4457.2013.00609.x?casa_token=Ewmct8h1fJkAAAAA%3A0D2xkY00T5vINd_1Bc5NmfHAMwN6P7j7TBujDTRDAWDrITiF8toeUkQ53F_dYKsZuhgBmZ_DNrbXCmLK

Holleman, C., & Conti, V. (2020). *Role of income inequality in shaping outcomes on individual food insecurity: background paper for the state of food security and nutrition in the world 2019-FAO agricultural development economics working paper 19-06*. Food & Agriculture Org. https://books.google.com.pk/books

Hossain, M. J., & Simi, R. A. F. (2024). Transformation for sustainable and nutrition sensitive food systems in Bangladesh: current status and future strategies. *Accelerating the Process of Transformation for Sustainable and Nutrition Sensitive Agri-Food Systems in South Asia*, *12*. https://www.sac.org.bd/wp-content/uploads/2025/01/Transformation-for-Sustainable-and-Nutrition-Sensitive-Agri-Food-Systems-in-South-Asia.pdf - page=46.16

IFAD (International Fund for Agricultural Development). (2020). *Rural development report*. IFAD. https://www.ifad.org/en/ar2020/

Ikudayisi, A. A., & Adejumo, O. (2025). Urban food security perspective towards sustainable development Goal 2: A bibliometric analysis. *Sustainable Futures*, *9*, 100654. https://doi.org/10.1016/j.sftr.2025.100654

Jorgenson, A. K., & Kuykendall, K. A. (2008). Globalization, foreign investment dependence and agriculture production: Pesticide and fertilizer use in less-developed countries, 1990–2000. *Social Forces*, *87*(1), 529-560. https://doi.org/10.1353/sof.0.0064

Khan, Y., Bojnec, Š., Lou, G., & Daraz, U. (2025). When poverty meets hunger: household vulnerability and coping responses to food insecurity in Torghar, Pakistan. *Agriculture & Food Security*. https://doi.org/10.1186/s40066-025-00588-3

Kishore, P., Birthal, P. S., & Srivastava, S. K. (2025). The Dilemma of Agricultural Price Policy Reforms: Balancing Food Security, Farmers' Interests, and Sustainability of Natural Resources. https://doi.org/10.22004/ag.econ.358869

Klerkx, L., Jakku, E., & Labarthe, P. (2019). A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. *NJAS - Wageningen Journal of Life Sciences*, 90-91, 100315. https://doi.org/10.1016/j.njas.2019.100315

© 2026 The Authors. Published under CC BY 4.0. | https://doi.org/10.66529/book.9786277945039.2026.ch2

Kurosaki, T. (2008). Crop choice, farm income, and political control in Myanmar. *Journal of the Asia Pacific Economy*, *13*(2), 180-203. https://doi.org/10.1080/13547860801923582

Ladha, J. K., Dawe, D., Pathak, H., Padre, A. T., Yadav, R. L., Singh, B., ... & Hobbs, P. R. (2003). How extensive are yield declines in long-term rice–wheat experiments in Asia? *Field Crops Research*, *81*(2-3), 159-180. https://doi.org/10.1016/S0378-4290(02)00219-8

Lencucha, R., Pal, N. E., Appau, A., Thow, A. M., & Drope, J. (2020). Government policy and agricultural production: a scoping review to inform research and policy on healthy agricultural commodities. *Globalization and health*, *16*(1), 11. https://doi.org/10.1186/s12992-020-0542-2

Liakos, K. G., Busato, P., Moshou, D., Pearson, S., & Bochtis, D. (2018). Machine learning in agriculture: A review. *Sensors*, 18(8), 2674. https://doi.org/10.3390/s18082674

Magdoff, F. (2013). Twenty-first-century land grabs. *Monthly review*, *65*(6), 1-18. https://www.social-ecology.org/wp/wp-content/uploads/2023/01/Magdoff-Land_Grabs.doc.pdf.

Manap, N. M. A., & Ismail, N. W. (2019). Food Security and Economic Growth. International Journal of Modern Trends in Social Sciences, 2(8), 108- 118. https://doi.org/10.35631/IJMTSS.280011.

Matchett, K. (2006). At odds over inbreeding: An abandoned attempt at Mexico/United States collaboration to "improve" Mexican corn, 1940–1950. *Journal of the History of Biology*, *39*(2), 345-372. https://doi.org/10.1007/s10739-006-0007-3

Mughal, M., & Fontan Sers, C. (2020). Cereal production, undernourishment, and food insecurity in South Asia. *Review of Development Economics*, *24*(2), 524-545. https://doi.org/10.1111/rode.12659

Mumah, E., Hong, Y., & Chen, Y. (2025). Exploring the reality of global food insecurity and policy gaps. *Humanities and Social Sciences Communications*, *12*(1), 1-23. https://www.nature.com/articles/s41599-025-05315-8

Parveen, F., Ahmad, T., Ahmad, M., Khan, N. W., Orakzai, J. K., & Islam, M. U. (2023). Food security, agriculture, climate change, policy implementation, soil fertility. *Khyber Journal of Public Policy*, *2*(4), 241-271. https://nipapeshawar.gov.pk/KJPPM/PDF/CIP/P39.pdf

Patel, R. (2009). Food sovereignty. *The journal of peasant studies*, *36*(3), 663-706. https://doi.org/10.1080/03066150903143079

Patel, R. (2013). The long green revolution. *The Journal of Peasant Studies*, *40*(1), 1-63. https://doi.org/10.1080/03066150.2012.719224

Petrikova, I. (2019). Food-security governance in India and Ethiopia: a comparative analysis. *Third World Quarterly*, *40*(4), 743-762.doi: 10.1080/01436597.2018.1538734

Pinstrup-Andersen, P. (2009). Food security: Definition and measurement. *Food Security*, 1(1), 5–7. https://doi.org/10.1007/s12571-008-0002-y

Ragasa, C.,Lambrecht, I., & Kufoalor, D. S. (2018). Limitations of contract farming as a pro-poor strategy: The case of maize outgrower schemes in Upper West Ghana. *World Development*, *102*, 30-56. https://doi.org/10.1016/j.worlddev.2017.09.008

Ray, D. K., Ramankutty, N., Mueller, N. D., West, P. C., & Foley, J. A. (2012). *Recent patterns of crop yield growth and stagnation. Nat Commun 3: 1293*. https://doi.org/10.1038/ncomms2296

Robinson, G. M. (2018). Globalization of agriculture. *Annual Review of Resource Economics*, *10*(1), 133-160. https://doi.org/10.1146/annurev-resource100517-023303

Ruel, M. T., & Alderman, H. (2013). Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition? *The lancet*, *382*(9891), 536-551. https://doi.org/10.1016/S0140-6736(13)60843-0

Sen, A. (1981). *Poverty and famines*: An essay on entitlement and deprivation. Clarendon Press.

Shaw, D. (2007). *World food security: A history since 1945*. Springer. https://link.springer.com/book/10.1057/9780230589780

Simon, G. A. (2012). Food security. *University of Roma Tre: Rome, Italy*. https://www.fao.org/fileadmin/templates/ERP/uni/F4D.pdf

Smith, L. C. (2013). The great Indian calorie debate: Explaining rising undernourishment during India's rapid economic growth. *International Journal of Sociology and Social Policy*, 33(1/2), 7–27. https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.2040-0209.2013.00430.x

Smith, M. D., Kassa, W., & Winters, P. (2017a). Assessing food insecurity in Latin America and the Caribbean using FAO's food insecurity experience scale. *Food policy*, *71*, 48-61. https://doi.org/10.1016/j.foodpol.2017.07.005

Smith, M. D., Rabbitt, M. P., & Coleman-Jensen, A. (2017b). Who are the world's food-insecure? New evidence from the Food and Agriculture Organization's food insecurity experience scale. *World Development*, *93*, 402-412. https://doi.org/10.1016/j.worlddev.2017.01.006

Subramanyam, M. A., Kawachi, I., Berkman, L. F., & Subramanian, S. V. (2011). Is economic growth associated with reduction in child undernutrition in India? *PLoS medicine*, *8*(3), e1000424. doi:10.1371/journal.pmed.1000424

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Tendall, D. M., Joerin, J., Kopainsky, B., Edwards, P., Shreck, A., Le, Q. B., ... & Six, J. (2015). Food system resilience: Defining the concept. *Global food security*, *6*, 17-23. https://doi.org/10.1016/j.gfs.2015.08.001

Thorndike, A. N., Gardner, C. D., Kendrick, K. B., Seligman, H. K., Yaroch, A. L., Gomes, A. V., ... & American Heart Association Advocacy Coordinating Committee. (2022). Strengthening US food policies and programs to promote equity in nutrition security: a policy statement from the American Heart Association. *Circulation*, *145*(24), e1077-e1093. https://doi.org/10.1161/CIR.0000000000001072

United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development* (A/RES/70/1). United Nations. https://sdgs.un.org/2030agenda

Von Braun, J., Afsana, K., Fresco, L. O., & Hassan, M. (2021). Food systems: Seven priorities to end hunger and protect the planet. *Nature*, 597(7874), 28–30. https://doi.org/10.1038/d41586-021-02331-x

WFP. (2009), "Hunger and Markets", World Hunger Series, WFP, Rome and Earthscan, London.https://www.wfp.org/support-us/stories/donate-now?utm_source=google&utm_medium=cpc&utm_campaign=12712293304&utm_content=120989103735&gclsrc=aw.ds&gad_source=1&gad_campaignid=12712293304&gbraid=0AAAAACOf4Hq3HbApbn7pply6xO41qQjvo&gclid=CjwKCAjw9NjRBhATEiwA_p2J8TBM51-4J3vNI0NBDUm0xVFEDZSfLLRkIzul0tzJUokhoARZtW7W3xoCatwQAvD_BwE

Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M. J. (2017). Big data in smart farming–a review. *Agricultural systems*, *153*, 69-80. https://doi.org/10.1016/j.agsy.2017.01.023

World Bank. (2022). *Food security and agricultural policy report*. World Bank Publications. https://thedocs.worldbank.org/en/doc/b5de315c82b1a3bb32bf30057aad9b74-0320012022/original/Food-Security-Update-LXVIII-Aug-11-2022.pdf

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CHAPTER 3

From Food Availability to Nutrition and Sustainable Food Systems

Maliha Sarfraz[1,*], Roma Saleem[1], Farwa Tariq[1], Umar Farooq[1] & Muhammad Farooq Khalid[1]
[1]University of Agriculture, Faisalabad, Constituent College, Toba Tek Singh, Pakistan
Corresponding author's email: maliha.sarfraz@uaf.edu.pk

Abstract

There has been a major transition of focus from calorie-dense food to nutrition security. However, this transition is not merely a shift in production priorities but reflects a broader transformation in global food systems governance and sustainability thinking. Merely increasing the production of yield to nutrient rich foods is now the objective by optimizing food systems that are not only sustainable but also environmentally friendly. This shift is prompted by the rising burden of both forms of malnutrition and non-communicable diseases, and global warming. Global warming and malnutrition both exert long- and short-term consequences. There is a dire need for sustainable multisectoral approaches that prioritize diet quality, nutrient-rich foods, climate health, and quality of life. Recent evidence also emphasizes the integration of climate-resilient agriculture, dietary transition policies, and food systems governance frameworks to address these interconnected challenges. Establishing sustainable dietary guidelines, eliminating subsidies for commodity crops, and adding cost to the foods with high environmental degradation will ultimately benefit the environment and reduce the risk of non-communicable diseases among the people. Changes in public policy that have double- or triple-duty actions that target all forms of malnutrition and climate need to be addressed. Climate change mitigation must be prioritized within national and global agendas. This chapter explores the opportunities, pathways, and challenges towards sustainable food systems using a systems-based analytical perspective.

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1. Food availability and nutritional security

Recently, emerging nations have experienced significantly faster growth than industrialized countries. The convergence of growth may have significant consequences for global food consumption and agriculture due to the rising need for agricultural resources as diets transition from starchy staples, as well as for our capacity to meet the sustainable goals. From a political economy perspective, these shifts also reflect structural inequalities in global food systems and uneven access to productive resources. The primary objectives of Sustainable Development include eradicating poverty and hunger, fostering inclusive economic growth, and diminishing inequality both within and across nations, which are strongly related to the issues of convergence and food demand. Researchers determined that the predominant characteristic of economic growth during the 19th century has been 'income divergence, significantly,' with initially less affluent countries seeing markedly slower growth than their more developed counterparts (Fukase and Martin, 2020).

This divergence continues to influence present-day disparities in food availability, nutrition outcomes, and agricultural productivity. Food access is the process of acquiring specific commodities (urban-produced) and encompasses educational, cultural, geographic, and economic dimensions. It is closely associated with the term food safety. In the food access literature, researchers identify challenges and opportunities for the expansion of healthful food access in low-income communities, with a particular emphasis on the utilization of urban-produced foods. Food access is therefore not only a logistical issue but also a structural outcome of governance, income distribution, and market systems. It is crucial to consolidate the literature on the production, access to, and utilization of urban-produced commodities in order to identify the effective strategies that urban farms implement to address the food access requirements of urban communities (Siegner *et al.*, 2018).

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Food and nutritional insecurity persistently impact society in both rich and developing nations, even during years of abundant harvests. This evidence affirms that the availability of food does not inherently equate to food safety and nutritional security. At times, food is abundant and available, but it is unacceptable or unsustainable. All such circumstances represent possible food and, particularly, nutritional vulnerability. Availability is characterized by researchers as the tangible presence of accessible food, whether sourced from personal agricultural production or acquired from external markets. National food availability includes commercial production, home production, food imports, foreign donations, and domestic food reserves. Food availability predominantly pertains to the accessibility of food at the household or regional levels (Riely *et al.*, 1999). The terms of food security and nutrition recognize that nutrition is an important part of food security, but it keeps the usual focus on food availability, stability, and access. Food and nutrition security stresses combine nutrition and food security in policies, programs, and studies (El Bilali *et al.*, 2019). However, the conceptual overlap between food security and nutrition security often leads to policy fragmentation, which this chapter addresses in later sections**.**

2. Determinants of food availability

Food supply depends on how much food is farmed or cultivated in a local area, how much food is exchanged in that area's markets, how much food is stored by traders or the government, and how much food is distributed by the government or other groups. So, the amount of food that is available in an area is closely related to how easy it is to grow food and how many places there are to buy food, including markets and food supply facilities. Some of these essential considerations are price, flavor, regional customs, and how easy it is to get.

Table 3.1. Determinants of Food Availability.

Factor	Description	Example
Agricultural production	Crop yield, farming systems	Rice and wheat production
Market access	Transportation	Rural and urban markets
Imports/exports	Trade policies	Food imports
Storage Government reserves	Government reserves	Grain silos

A person's socioeconomic status and how simple it is for them to access food also affect the kinds of foods they buy and the nutrients they get. People's choices have a direct impact on nutrition and sustainability. The amount of money people have and the kinds and amounts of food that are available also have an effect on these things (Cohen and Lucero Prisno, 2025).

Agricultural Production Systems
Fisheries, Livestock & Crop Sectors
Impact of Climate Change
Food Availability Determinants
Post-Harvest Losses & Food Wastage

Figure 3.1. Key Determinants of Food Availability

2.1 Agricultural production systems

Around the world, agricultural production systems are facing big problems, such as climate change, a lack of water for irrigation, rising production costs, and a general drop in farm labor over the last few decades.

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Anyway, the most recent problem, the COVID-19 pandemic, could make it hard for everyone to grow and give food. These things put at risk the economic and natural stability of food supply systems now and in the future. Thanks to progress in science, we now have a better idea of how different parts of agriculture work together, from the level of the cell to the level of the land. Genetic tools have come a long way in the last few decades, but until recently, we didn't have a good way to accurately check large groups of crops in the field. New technologies like remote tracking and AI can make agricultural systems more resilient. We will also create a unique chance to create the tools needed to solve the next ten years' worth of food and farming problems (Jung *et al.*, 2021).

2.2 Role of fisheries, livestock, and crop sectors

In the last 50 years, the main sources of food around the world have changed from grains to animal protein. This has led to a huge rise in livestock and fish production, but it also makes energy use more efficient. Proteins, vitamins, and micronutrients that aren't found in as large amounts or types of crops or other animal goods can be found in fish and shellfish. With the world's population growing quickly, it's hard for global agriculture to produce enough food to meet rising demand while also dealing with climate change. In the past 70 years, modernization, industrialization, and mechanization in agriculture have put a lot more pressure on land used for farming. This has made environmental issues worse. Using an integrated crop and livestock system on a farm can help farmers make a lot of money and provide a wide range of food for their families if it is handled correctly. ICLS can change the variety of foods that people eat, help small-scale subsistence farms make more money, and lower economic risks (Sekaran *et al.*, 2021).

2.3 Impact of Climate change on food supply

Food production systems are now facing more hurdles because of climate change, limited land and water, and most recently, a pandemic. Developing countries' farming systems are at greater risk because of global warming. To make the agricultural system more resistant to changing weather, adaptation steps and the use of new technologies need to be practiced. Even though there are agricultural methods that can help farmers adapt to climate change, the institutions that can put these technical solutions into action and spread the word about them need to be strengthened. To make the necessary institutional changes, get the money to spend on these changes, and come up with dynamic policies for lifetime climate variation modification in related fields (Aryal *et al.*, 2020).

Table 3.2. Impact of Climate Change on Food Security (Wijerathna-Yapa and Pathirana, 2022).

Sr. No	Climate Factor	Important Changes	Impact on Food Production
1	Increase in temperature	Heat waves increase the temperature beyond the normal range	Reduced the yield of crops like wheat and maize
2	Irregular Rainfall	A change in pattern causes floods and drought in the environment	Disturbance in planting cycles causes lower production
3	Drought	Water scarcity	Crop production is lower due to a shortage of water resources
4	Global Warming	Carbon dioxide levels increase in the atmosphere	Temperature increases due to carbon dioxide. High temperature damages protein structure and lowers crop production
5	Pest production	The environment favors the growth of pathogens.	Pesticides demand increases

2.4 Post-harvest losses and food wastage

A very important part of farming is post-harvest management, which includes several tasks and practices that are meant to keep and improve the quality and worth of crops that have been harvested from the fields. As the number of people grows, so does the demand for fresh-cut fruits and veggies. At the same time, popular vegetables are available all year round the world. This means that post-harvest losses, which can be big, need to be kept to a minimum in a world with complicated markets and supply lines. When sweet corn is picked before it's physiologically mature, the seed has a lot of water and sugar in it. This makes it very

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perishable fresh food that needs to be handled properly after harvest to keep it fresh and prevent loss of quality. The most important things to keep are the taste, smell, and color, since those are the things that customers like the most. Loss of sweetness and dryness are two of the problems that can happen to sweet corn after it has been picked. Implementing effective post-harvest methods not only protects farmers' hard work but also makes a big difference in lowering hunger and malnutrition (Nishad *et al.*, 2024).

3. Determinants of Food Access and Utilization

3.1 Socio-economic determinants of food access

Since each region in a country has its own culture and socioeconomic position, putting all of those differences into one region may lead to mistakes and wrong results, which is what most studies do. People from racial and ethnic minority groups and lower socioeconomic class (SES) are more likely to not have enough food, live in places that don't have enough food resources, and continue to have the most diet-related chronic diseases. It's hard for about 13.5 million people in the US to get to big grocery stores, which means they can't get fresh food. A recent longitudinal study found that a better diet was linked to being close to and having a lot of food shops, as well as to having a high-socioeconomic status (SES) in the neighborhood and thinking that the area had healthy food options. These links were stronger in racial and ethnic minority groups (Odoms-Young *et al.*, 2024)

3.2 Household food distribution

Household food insecurity is becoming increasingly recognized as a global health issue, particularly in Sub-Saharan Africa. The imperative necessity of addressing food insecurity in order to achieve human rights by 2030 has been underscored by the Sustainable Development Goals (SDGs). The primary objective is to end poverty in all its forms, while the secondary objective is to remove hunger and achieve food security. Food security is achieved when all individuals have constant physical and economic access to a sufficient amount of safe, nutritious food for a healthy existence (Drammeh *et al.*, 2019).

Figure 3.2. Key Determinants of Food Access and Utilization

3.3 Cultural and behavioral factors

People of a certain area or social group eat in a certain way. Cultural dietary routine includes the things they eat and the way they think about food. Material factors include methods for growing, transporting, and distributing food; money; place and time to prepare meals. Kids learn how to handle food by watching their parents do it. Mealtime schedules, where and when to eat (at the table, with other people, etc.), and how to eat (e.g., proper eating habits and enjoying food) are all taught by social groups like families, schools, and peers. The same experiences that shape learning also shape how people think about and feel about food and eating. This passing on is one reason why food practices have stayed mostly the same over time. When immigrants are introduced to new foods and different ways of cooking and getting food, their cultural food habits change. This is called acculturation (Monterrosa *et al.*, 2020).

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4. Food safety and quality considerations

Quality of food is simply how well the natural qualities of a food product or service meet customer needs. It is a changing part of food that determines how important or acceptable it is to customers. The scientific idea of food safety is talked about under the heading of food quality. This section goes into detail about how to handle, prepare, distribute, and store food so that it doesn't get contaminated and people don't get sick. As a matter of public health, it's growing more important. There is a difference between food quality and food safety. Food safety is about making sure that safe food is eaten by everyone. Both of these ideas require that food be made that is safe and healthy for people to eat. Because food quality and safety are so important, major focuses on different quality systems and food safety management systems, how they get approved according to the latest standards, and the requirements that need third-party checks (Farooq *et al.*, 2021).

5. Food Security to Nutritional Security

Food and nutrition security (FNS) does not always mean that food is available. Even if food is available, it might not be easy for everyone who needs it to get it. Also, food that is available and easy to get might not always have all the nutrients the body needs to grow, develop, fight off sicknesses, and meet its normal physiological needs. Food is sometimes easy to get and plenty, but it's not always good or viable. Food and nutrition security can only be reached when everyone has the physical and financial means to get enough healthy food to meet their dietary needs and make healthy lifestyle decisions (Simelane and Worth, 2020).

Table 3.3. Comparison of Food Security and Nutrition Security

Parameter	Food Security	Nutritional Security
Definition	Food access to sufficient quantities	Accessibility to adequate food fulfilling nutritional requirements
Area of focus	Food quantity Quantity of food	Quality and nutritional aspects of food
Key Concern	Food scarcity and hunger	Malnutrition and micronutrient deficiencies
Objective	To make sure people are not hungry	People are well nourished and nutritionally secure
Example	Availability of enough staple food (wheat or rice)	Access to a balanced diet with macro and micronutrients
Indicators	Food supply, food prices, and income	Nutritional status (Body mass index, stunting, wasting, etc.)

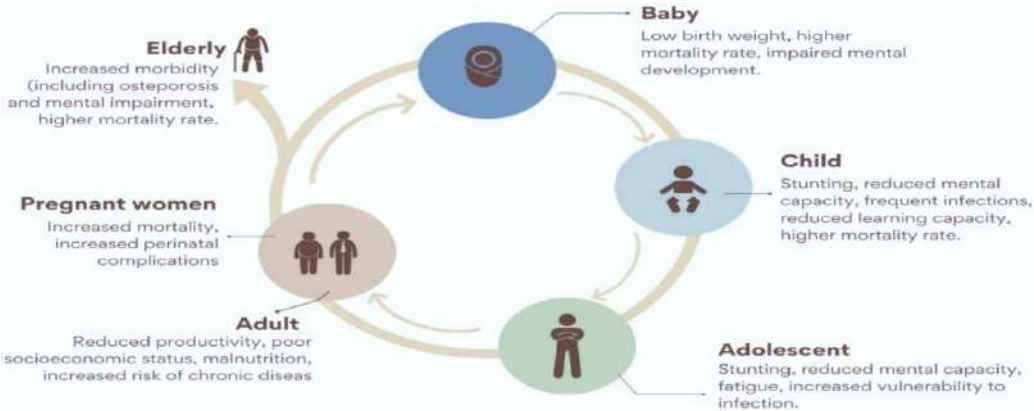
Baby
Low birth weight, higher mortality rate, impaired mental development.
Child
Stunting, reduced mental capacity, frequent infections, reduced learning capacity, higher mortality rate.
Adolescent
Stunting, reduced mental capacity, fatigue, increased vulnerability to infection.
Adult
Reduced productivity, poor socioeconomic status, malnutrition, increased risk of chronic diseas
Pregnant women
Increased mortality, increased perinatal complications
Elderly
Increased morbidity (including osteporosis and mental impairment, higher mortality rate.

Figure 3.3. Effects of Nutrient Deficiency through the Developmental Cycle (Ofori *et al.*, 2022)

The most important parts of a good diet are macronutrients and micronutrients. Protein, carbs, fats, vitamins, and minerals must be in the right amounts for a healthy body. Different people have different daily needs because of their age, gender, weight, level of exercise, and overall health. Micronutrients are things that the

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body needs, like vitamins and minerals. They do more than one thing and often work better together. Macronutrients are made up of carbs, fats, and proteins, and they make up most of the body's soft tissues. Macronutrients, which are made up of fat, protein, and carbs, give you energy and important building blocks for your body. Micronutrients are needed to keep this process of building and rebuilding going repeatedly. Because of this, each person's micronutrient needs will be different because of their different biochemical states at different times in their life. High demand for tiny nutrients is vital during conception. If there isn't enough of them, it could affect physical and even cognitive growth (Gush *et al.*, 2021).

Malnutrition is defined by the absence of micronutrients, which leads to undernutrition and obesity, particularly in adolescents. Hidden hunger is the insidious and clinically undetectable absence of micronutrients. Healthy eating is one of the recommended actions in caregiving, which includes the prevention of nutritional deficiencies. According to data from the Food and Agriculture Organization (FAO), 852 million individuals in developing countries experienced chronic starvation in 2005. Hunger affected 16.4% of the Caribbean population, 8.4% of the population in Mesoamerica, and 7.9% of the population in South America between 2019 and 2021. Researchers estimated that over 2 billion individuals across the globe are at risk of experiencing micronutrient deficiencies. Over one billion individuals suffer from micronutrient deficiencies, which manifest as anemia, vitamin A deficiency, or even cognitive impairment, as a consequence of nutritional deficiencies that began during childhood (Weffort and Lamounier, 2024).

5.1 Dietary diversity and balanced nutrition

Diversity in food consumption is a general measure of food consumption that shows how easy it is for households to get different kinds of food and how good the food that is eaten is. Eating a variety of foods is thought to provide all the essential nutrients, but it is important to check one's nutritional status. Toddlers and kids younger than five years old have problems with eating every day because they aren't getting enough food. Not getting enough of certain nutrients because of limited food choices has been linked to low birth weight, under-nutrition, starvation, stunting, and other nutrition issues. Therefore, steps need to be taken to ensure a healthy diet that provides food and nutrition security for everyone in a way that doesn't hurt future generations (Ardianti *et al.*, 2021).

5.2 Public health implications

Metabolic diseases have risen significantly over the past two decades. Diabetes, heart disease, and hypertension are among the most common disorders. Sedentary lifestyle and high-fat diet are the common but modifiable risk factors. Another common disease, such as severe periodontitis, is the sixth most common disease and affects about 11.2% of the world's adult population. This makes it a big problem for healthcare, society, and the economy. New scientific findings explain the links between periodontitis and other diseases (Genco and Sanz, 2020). People of all ages around the world often don't get enough sleep. This is seen as a public health epidemic that isn't fully noticed or reported, and it costs a lot more money. Not getting enough sleep can interfere with the body's normal processes, which can lead to heart disease, diabetes, obesity, and other neural problems. The problem is getting worse because more people are using smartphones and other electronics (Chattu *et al.*, 2018). Since the 1990s, globally, the economy and people's habits have changed. At the same time, the prevalence of obesity has risen. According to Chinese standards, about half of adults and one-fifth of children are overweight or obese. China is in a good position to look for a way to deal with the obesity problem. But the national and local governments need to be very committed and take the lead. All relevant parts of society and individual citizens also need to be involved (Wang *et al.*, 2021).

6. Sustainable Food Systems

A sustainable food system is one that fulfills current food needs with healthy food while maintaining healthy ecosystems that can also provide food for future generations. Sustainable Development Goals (SDGs) are a set of global goals aimed at making the future sustainable for future generations. Note that changing food systems is very important because the way they work now can't last forever. Sustainability is now a main goal and a guiding concept for human progress. Concerns around the world include environmental damage, social unrest, and changes in the economy. These issues are challenging traditional ideas about growth and

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making us rethink how we act every day. Food technology and governmental science are both important parts of making the transition to a sustainable food system easier (Hariyadi, 2024).

6.1 Environmental sustainability

There are two reasons why the food we consume today is unsustainable: the food system is depleting non-renewable resources and causing unacceptable environmental damage. Our food is classified as residual food due to its dependence on fossil fuels, non-renewable mineral resources, the depletion of groundwater reserves, and the excessive loss of soil. Global endeavors to regulate and manage the human food supply are fundamentally rooted in the concept of sustainable food systems. Eco-friendly development is the conservation and waste management of the natural resource base, and an assessment of improvements in technology and institutions in such a manner as to ensure the achievement and uninterrupted satisfaction of human needs for all future generations. It also conserves land, water, plant, and animal genetic resources. Modifications require the use of internet technology, specifically in the form of food from the internet. This technology provides the opportunity to more effectively utilize international resources, to establish systems of resilience, and to promote responsible governance through education and trade, which are not constrained by knowledge and access (Holden *et al.*, 2018).

6.2 Climate-resilient agriculture

Climate Resilient Agriculture for Achieving Food Security fully tackles critical aspects of climate-vulnerable agriculture for food security through the implementation of mitigation and adaptation approaches. The issue of future food safety is likely to be exacerbated by the pressure on agriculture that climate change and increasing variability will exert. Structure of the atmosphere gas has undergone substantial changes over the past few decades, primarily due to higher greenhouse gas emissions from industry, and agricultural farms, as well as deforestation and methods of land management. To enhance food security and adapt to changing weather and natural resource pressures, agriculture and food systems must also contribute to climate change mitigation. Climate-resilient agriculture is a sustainable approach to increasing agricultural productivity and incomes, adapting and constructing resilience to climate change, and reducing emissions of greenhouse gas (Meena *et al.*, 2026).

6.3 Integrated aquaculture and livestock systems

Integrated farming systems are an acceptable choice for strengthening sustainability in the face of environmental pollution, climate change, and soil degradation. The multidimensional effects of these various forms of environmental destruction of the environment deform the foundation of agricultural production.

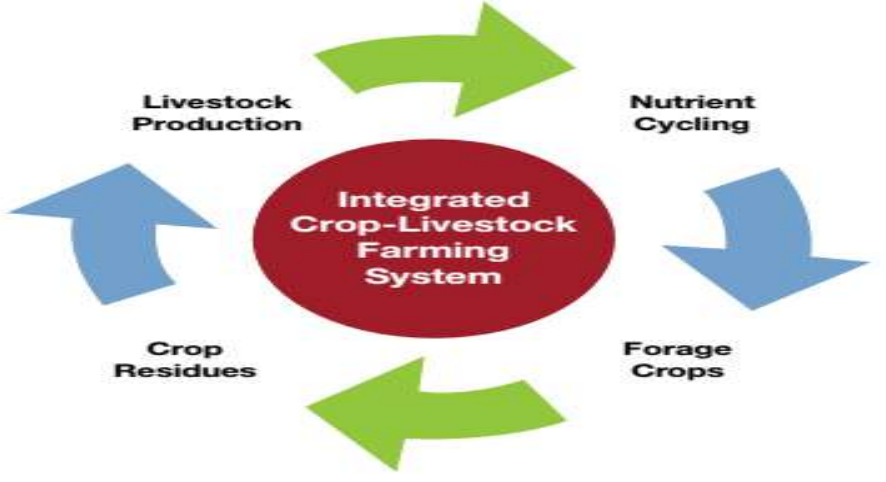

Figure 3.4. Integrated Farming System including Crops, Livestock, and Nutrient Cycling.

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The socio-ecological capacities of farmers to sustain their livelihoods are improved by the integrated agricultural systems strategy. Consequently, the most advanced approach of environmentally friendly agriculture is farm management systems, which depend on the integration of key components of agriculture, including crops, livestock, and aquaculture. The mixed system of livestock management provides a variety of advantages and a more effective response to climate change by enhancing the production of crops and livestock and reducing greenhouse gas emissions. Modification levels are broadly categorized as food-based, DNA-management, and the use of communication technology (Bhattacharyya *et al.*, 2020).

6.4 Resource-efficient food production

The food and beverage industry is currently highly inefficient due to the significant amount of food scraps it produces, as well as the significant amounts of water and energy it consumes. This issue is further exacerbated by the tightening of regulations regarding the treatment and elimination of food waste, greenhouse gas emissions, and wastewater discharge, as well as the increased economic costs. Consequently, resource efficiency is essential for the development of a sustainable food system. It is imperative to implement transparent and precise real-time monitoring to mitigate food waste, energy consumption, and water consumption in order to comprehend the genuine causes of their generation and utilization. These factors would facilitate the innovation of food production mechanisms and the attainment of operational enhancements. Smart items like the Internet of Things, a relatively new manufacturing concept within Industry. :The performance of production systems can be significantly impacted by the information technology infrastructure (Jagtap, 2019).

6.5 Circular economy in food systems

The circular economic system replaces the concept of end-of-life. Its major objective is to replace the prevailing model of linear economics. This model involves the extraction of raw materials from the environment and their processing into final products. These products are intended for a single purpose and have a short lifespan. The concept of the circular economy is to minimize the environmental impact of these products by extending their life cycle. It operates at different levels for achieving balanced development. Industrial systems should follow the idea of a zero-waste economy (Hamam *et al.*, 2021).

Figure 3.5. Integrated Framework for Sustainable Food Systems

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7. Food Systems Approaches

7.1 Components of food systems

Food systems comprise the individuals and activities that are responsible for the production, transportation, supply, and consumption of food. The food supply chain encompasses the following stages: agricultural production, transportation and distribution, manufacturing, packaging, and retail. The activities within the food supply chain are intricately linked to one another. Ecosystem services and feedback mechanisms are influenced by drivers that regulate food system operations. A balanced food system is the ability of a system and its components to function at different levels to provide sufficient and reachable food to all. Complex food systems are necessary to prevent disruptions and to develop the adaptive capacity to adapt to the changes in the operating environment, which is characterized by multidimensional changes (Rimhanen *et al.*, 2023).

7.2 Food production, processing, distribution, and consumption

An integrated strategy balances optimal production with changes in food utilization. It is necessary to establish balanced food systems. Main points for enhancing the food resilience of an area that seeks to increase its efficiency: (i) Enhancing technical solutions, (ii) Increasing community engagement, (iii) Enhancing agricultural variety, and (iv) Implementation of an integrated system in food planning. The interests of stakeholders in the food chain must be coordinated in order to ensure the sustainability of the consumption and production areas (Menconi *et al.*, 2022).

7.3 Role of technology in food systems

Sustainable food systems need new and advanced technologies. These technologies can help us find answers to some of the most important questions we need to ask in order to change SFSs and learn more about world food safety and nutrition protection. New technologies have an effect on how SFSs change. Some innovations include better ways to use farming land, process food, make production systems work better, change people's diets to fit their needs, and deal with waste. What are some new technologies being used in digital agriculture? The Internet of Things (IoT) is AI and machine learning devices like drones, self-driving cars, and advanced materials like gene technology. Right incentives, rules, and social permits are very important for getting more people to use current technologies to support the sustainable food systems (Khan *et al.*, 2021).

7.4 Urbanization and changing food patterns

Africa's food and environmental systems are being greatly affected by rapid urbanization. As cities grow, agricultural or natural lands may be taken over, and these could diminish food production and biodiversity. Land-use displacement effects can either make up for lost agricultural production or cause even more biodiversity loss. Changing lifestyles, jobs, and incomes in cities are quickly affecting people's food choices and supply, such as the modernization of food systems and environments (de Vos *et al.*, 2024).

8. Role of Policy and Governance

8.1 National and international food policies

The world has a lot of people who don't have enough food, and hunger and malnutrition are still going to be big problems, especially in developing countries with low incomes. It is expected that the effects of environmental change will be especially hard on agriculture in those countries over the next 30 years. International markets are used for trading basic agricultural goods in the future. Countries with free trade policies can use their comparative advantages in the economy to boost average per capita incomes, long-term growth rates, and their ability to pay for social safety nets for the poor. So, the challenge for policymakers is to find a balance between the best lifetime policies and temporary efforts to improve food security (Smith and Glauber, 2020).

8.2 Institutional frameworks

Theoretical frameworks of food system governance may make complicated things easier to understand, but they might not take into account things that happen outside of their frameworks or the practical issues that

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affect actual governance efforts. Frameworks include different food networks, bioregions, and food sheds. They also use examples from real-life experiences to show what practical factors are used in these kinds of initiatives. It comes to the following conclusions: a) localized complaints shape how governments act; b) globalization and localization don't have to be separate; and c) different points of view are important, but markets are necessary for food systems (Arthur *et al.*, 2022).

8.3 Nutrition-sensitive agriculture

There are major nutrition problems in almost every country in the world today, 70 years after the end of the last major war. Nutrition is seen as both a part of and a result of sustainable development. Food production is also an important part of this. Nutrition-sensitive agriculture (NSA) programs have sprung up to support things like changing crops, teaching people about nutrition, and giving women more power. A lot of research has been done on whether or not NSA programs affect nutrition indicators. But not as much research has been done on whether or not these programs are fair in terms of distribution, process, and recognition (Nichols, 2020).

8.4 Food system transformation strategies

Food system transformation needs scientific understanding and analysis of the interactions between system components. The objectives of food systems challenge socio-political policies. Different systems emphasize specific types of interventions for achieving system change. They argue that food systems are best viewed as multi-directional systems. Based on these insights, researchers have identified critical governance strategies and principles employed to affect the variation of the food system as a long-term and non-linear process of negotiation, reconfiguration, and competition. Governance interventions need a significant reorientation of investments in the dairy system, and a reevaluation of the role of policymakers in either modifying or perpetuating undesirable systemic outcomes (Leeuwis *et al.*, 2021).

9. Emerging Innovations

9.1 Biofortification

Micronutrient insufficiency causes a serious and difficult problem. Biofortification is seen as an effective and long-term way to deal with this problem because it manages nutrients. Biofortification uses many different methods, including agronomic practices (like adding minerals or microbes) and molecular and genetic engineering techniques, along with traditional plant breeding. All of these methods add important nutrients to plants, like provitamin A, vitamin C, iron, zinc, calcium, iodine, and selenium, while lowering harmful substances and trypsin inhibitors in basic foods (Labuschagne, 2023).

Figure 3.6. Importance of Biofortification in the Food Chain (Walsh *et al.*, 2025).

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9.2 Green nanotechnology in food production

Nanotechnology has led to a lot of research in the last few decades, especially in engineering, biotechnology, food technology, medical sciences, and agriculture. The bulk material is broken up into tiny particles with one or more dimensions in the nanometer range or even smaller. These particles have surprising properties that are different from those of the bulk material. Nanomaterials have unique properties that make plants more resistant to disease, help find mycotoxins in food, make better use of nutrients, and boost plant growth. Bio-Nanotechnology uses biological ideas along with chemical and physical methods to create very small particles that have specific jobs to do. This is also a cheaper alternative to using chemicals or physical methods to make nanoparticles. Nanotechnology is a new technology that is getting a lot of attention in the food system because it can help with processing, safety, and packaging food. Nanotechnology can be used in food production to improve the overall quality of food, such as its taste, flavor, and bioavailability (Mohammad *et al.*, 2022).

9.3 Precision agriculture

Precision agriculture (PA) uses computers to better manage the production of crops and animals. It is seen as another way to improve food privacy around the world. Precision agriculture (PA) to boost output, make better use of resources like water, feed, and labor, pesticides, and fertilizers, make production more stable, and lower the damage that farming does to the environment. PA, on the other hand, can look very different depending on the type of crops and animals raised, the size of the farm, how it is managed, how easy it is for the farm to get technical help, and the age and education level of the operator (Erickson and Fausti, 2021).

9.4 Smart aquaculture and fisheries management

The world is facing labor shortages in agriculture because young adults aren't working enough, and the agricultural population is getting older. This will have an effect on aquaculture production. Aquaculture farming has some problems that can be fixed by creating a smart aquaculture-based fish tracking and control system with various smart devices that can collect data in real time. This way, the quality of the water in fishponds and other system parameters can be easily checked, changed, and evaluated from afar. AIoT-based aquaculture systems can check the water quality and microclimate at the same time. Another thing that an AIoT system can do is collect data from sensors and feed data that can help make aquaculture more accurate and smarter. Smart aquaculture cuts down on work, keeps water quality stable, saves energy, and makes sure fish are fed correctly (Chiu *et al.*, 2022).

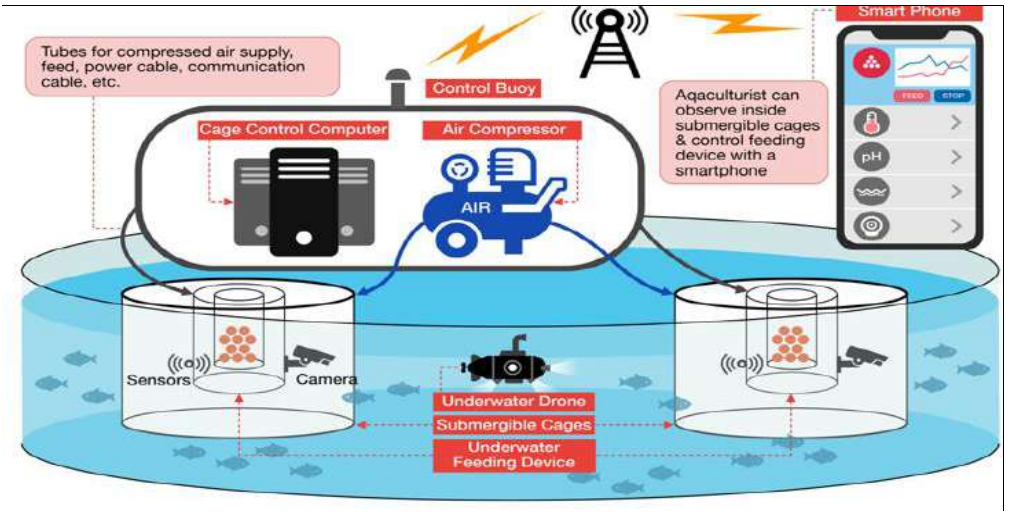

Figure 3.7. Smart Aquaculture System (Vo *et al.*, 2021).

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10. Challenges and Future Perspectives

10.1 Population growth

A significant obstacle to the attainment of global food safety is the consistent growth of the global population, which is projected to reach nine billion individuals by 2050. Consequently, it is imperative to urgently address the necessity of feeding an expanding international population and adequately addressing the consequences of climate change. The application of molecular and genetic mechanisms to the development and/or enhancement of agricultural and industrial processes may facilitate progress. Food security is the foundation of any nation. The major target of the food system is to accommodate a rapidly expanding population and to facilitate urbanization. Nevertheless, a billion individuals worldwide endure chronic hunger daily. Individuals should have access to sufficient quantities and quality of food at reasonable prices to ensure they can live without hunger and eliminate malnutrition by providing food and nutritional security from a human life cycle perspective. Additionally, scientists are exploring methods to repurpose agricultural and food waste in the emerging market (Ghosh *et al.*, 2024).

10.2 Climate variability

It is expected that atmospheric change will have a huge impact on food systems all over the world, often in ways that make existing weaknesses and unfairness worse between societies and regions of the world. The good news is that there are already a lot of practices, technologies, knowledge bases, and social networks that can help us deal with climate change positively. These include ways to both reduce its effects and adapt to them, as well as ways to make these efforts work better together and help other important goals, like protecting biodiversity and other ecosystem services. Because of this, food systems should and can be a bigger part of climate policies. Short-term, changes in policies and support systems that help the poor can quickly bring about a wide range of positive effects that go far beyond food systems. Long-term, we need to put money into research right away to make sure that future generations will have food security and a healthy ecosystem (Wijerathna-Yapa and Pathirana, 2022).

10.3 Resource scarcity

Even though the psychology of resource scarcity is a new field of study, the idea that resource scarcity happens everywhere is a basic idea in modern economics. As a result, the resources we need to meet our needs are always limited. These include labor, capital, time, and food for consumption. This means that any sensible person has to put efficiency first and talk about how to make the best use of their resources (Isler, 2021).

10.4 Food inequality

As the world's communities continue to grow, issues of human rights and the unequal distribution of food resources have become more important. New ways to look into the connection between inequality at the country level and violations of human rights in the way biophysical resources are distributed and food is made available. More research needs to be done in the future to fully understand these dynamics and start coming up with ways to help people who don't have equal access to food. It will also be important to look more closely at how trade policies affect patterns of agricultural development, crop production, and yields (D'Odorico *et al.*, 2019).

10.5 Need for integrated food system planning

No universal approach exists for planning of local food systems and sustainability. Planning must strike a balance between the necessity of being comprehensive and place-based. In part, the future of food systems is contingent upon the establishment and maintenance of a combined food system that transparently considers a diverse array of eco-friendly parameters at the national and global levels. A global food system that is integrated promotes adaptive strategies while also recognizing the unique objectives of local communities. The objective of an integrated food system is to address a variety of local needs and national and international partnerships that are mutually beneficial (Issac *et al.*, 2022).

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11. Conclusion

The food system transformation addresses safety, inequalities, hunger, and sustainability. This strategy will also support several interrelated goals, including the SDGs. In the future, it will be necessary to increase the availability of food to all citizens, regardless of their status, and to enhance national sensitivity by providing high-quality food. Numerous policy modifications and interventions that are recommended have the potential to benefit the environment, nutrition, and food availability (Hendriks *et al.*, 2023). The rehabilitation of the food crisis has been a collaborative effort between numerous nations and European Union policymakers. It has included the initiation of resource recycling and the implementation of modern techniques for the sustainability of natural food sources. Renewable livelihood strategies recognize the interactions of water, energy, and food as a single system during the assessment of the manmade and natural surroundings. Genetically modified food will contribute to the resolution of the food system issue by twenty to fifty percent, as well as the creation of employment opportunities for farmers and the establishment of sustainable food security worldwide. Horizontal gene transfer is essential for the prevention of crop disruption and the integration of new dynamic techniques to ensure global food insurance by minimizing and controlling pathogen infections. The organization is establishing a framework in developing countries to enhance the efficiency of agricultural resource systems and to ensure individuals have access to nutritious food. The regulation of food safety and security can be achieved through the enhancement of agricultural industrialization and the management of natural resources.

The evolution of broader and more integrated policies is required for addressing the multiple sectoral approach, including production, distribution, ecological effects, and social. These factors will be facilitated by the active engagement of these stakeholders. Policymakers adhere to the following guidelines during the policy-making process: The drivers of the food system and their interactions should include nutrition policy for the best achievements. In the development of nutrition policy, policymakers should capitalize on consumer health trends. The packaged food and food service sectors could be aligned in terms of nutrition policy coherence by policymakers.

References

Ardianti, R. D., Salimo, H., & Cilmiaty, R. (2021). The effect of dietary diversity on nutritional status in Indonesian children: A review. *International Journal of Nutrition Sciences*, *6*, 119–125. https://doi.org/10.30476/IJNS.2021.90861.1130

Arthur, H., Sanderson, D., Tranter, P., & Thornton, A. (2022). A review of theoretical frameworks of food system governance, and the search for food system sustainability. *Agroecology and Sustainable Food Systems*, *46*, 1277–1300. https://doi.org/10.1080/21683565.2022.2104422

Aryal, J. P., Sapkota, T. B., Khurana, R., Khatri-Chhetri, A., Rahut, D. B., & Jat, M. L. (2020). Climate change and agriculture in South Asia: Adaptation options in smallholder production systems. *Environment, Development and Sustainability*, *22*, 5045–5075. https://doi.org/10.1007/s10668-019-00414-4

Bhattacharyya, P., Pathak, H., & Pal, S. (2020). Livestock and aquaculture management for climate-smart agriculture. In *Climate smart agriculture: Concepts, challenges, and opportunities* (pp. 113–127). Springer. https://doi.org/10.1007/978-981-15-9132-7_8

Chattu, V. K., Manzar, M. D., Kumary, S., Burman, D., Spence, D. W., & Pandi-Perumal, S. R. (2018). The global problem of insufficient sleep and its serious public health implications. *Healthcare*, *7*(1), 1. https://doi.org/10.3390/healthcare7010001

Chiu, M.-C., Yan, W.-M., Bhat, S. A., & Huang, N.-F. (2022). Development of smart aquaculture farm management system using IoT and AI-based surrogate models. *Journal of Agriculture and Food Research*, *9*, 100357. https://doi.org/10.1016/j.jafr.2022.100357

Cohen, M. J., & Lucero-Prisno, E., III. (2025). *Advances in food security and sustainability*. Academic Press.

de Vos, K., Janssens, C., Jacobs, L., Campforts, B., Boere, E., Kozicka, M., Leclère, D., Havlík, P., Hemerijckx, L.-M., & Van Rompaey, A. (2024). African food system and biodiversity mainly affected by urbanization via dietary shifts. *Nature Sustainability*, *7*, 869–878. https://doi.org/10.1038/s41893-024-01362-2

D'Odorico, P., Carr, J. A., Davis, K. F., Dell'Angelo, J., & Seekell, D. A. (2019). Food inequality, injustice, and rights. *BioScience*, *69*(3), 180–190. https://academic.oup.com/bioscience/article/69/3/180/5320252

Drammeh, W., Hamid, N. A., & Rohana, A. J. (2019). Determinants of household food insecurity and its association with child malnutrition in Sub-Saharan Africa: A review of the literature. *Current Research in Nutrition and Food Science Journal*, *7*(3), 610–623. http://dx.doi.org/10.12944/CRNFSJ.7.3.02

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El Bilali, H., Callenius, C., Strassner, C., & Probst, L. (2019). Food and nutrition security and sustainability transitions in food systems. *Food and Energy Security*, *8*(4), e00154. https://doi.org/10.1002/fes3.154
Erickson, B., & Fausti, S. W. (2021). The role of precision agriculture in food security. *Agronomy Journal*, *113*(6), 4455–4462. https://doi.org/10.1002/agj2.20919
Farooq, U., Shafi, A., Shahbaz, M., Khan, M. Z., Hayat, K., Baqir, M., & Iqbal, M. (2021). Food quality and food safety: An introduction. In *Sequencing technologies in microbial food safety and quality* (pp. 3–24). CRC Press. https://doi.org/10.1201/9780429329869
Fukase, E., & Martin, W. (2020). Economic growth, convergence, and world food demand and supply. *World Development*, *132*, 104954. https://doi.org/10.1016/j.worlddev.2020.104954
Genco, R. J., & Sanz, M. (2020). Clinical and public health implications of periodontal and systemic diseases: An overview. *Periodontology 2000*, *83*(1), 7–13. https://doi.org/10.1111/prd.12344
Ghosh, A., Kumar, A., & Biswas, G. (2024). Exponential population growth and global food security: Challenges and alternatives. In *Bioremediation of emerging contaminants from soils* (pp. 1–20). Elsevier.
Gush, L., Shah, S., & Gilani, F. (2021). Macronutrients and micronutrients. In *A prescription for healthy living* (pp. 255–273). Elsevier. https://doi.org/10.1016/B978-0-12-821573-9.00023-0
Hamam, M., Chinnici, G., Di Vita, G., Pappalardo, G., Pecorino, B., Maesano, G., & D'Amico, M. (2021). Circular economy models in agro-food systems: A review. *Sustainability*, *13*(6), 3453. https://doi.org/10.3390/su13063453
Hariyadi, P. (2024). Sustainability of food systems: The role of food technology and regulatory science. *BIO Web of Conferences*, *98*, 03003. https://doi.org/10.1051/bioconf/20249803003
Hendriks, S., Soussana, J.-F., Cole, M., Kambugu, A., & Zilberman, D. (2023). Ensuring access to safe and nutritious food for all through the transformation of food systems. In *Science and innovations for food systems transformation* (pp. 31–58). Springer. https://doi.org/10.1007/978-3-031-15703-5_4
Holden, N. M., White, E. P., Lange, M. C., & Oldfield, T. L. (2018). Review of the sustainability of food systems and transition using the Internet of Food. *npj Science of Food*, *2*, 18. https://doi.org/10.1038/s41538-018-0027-3
Isler, O. (2021). Resource scarcity. In *Encyclopedia of evolutionary psychological science* (pp. 6647–6649). Springer. https://doi.org/10.1007/978-3-319-19650-3_1585
Issac, J., Newell, R., Dring, C., White, C., Ghadiri, M., Pizzirani, S., & Newman, L. (2022). Integrated sustainability planning and local food systems: Examining areas of and gaps in food systems integration in community sustainability plans for municipalities across British Columbia. *Sustainability*, *14*(11), 6724. https://doi.org/10.3390/su14116724
Jagtap, S. (2019). *Utilising the Internet of Things concepts to improve the resource efficiency of food manufacturing* [Doctoral dissertation, Loughborough University]. https://doi.org/10.26174/thesis.lboro.11180456.v1
Jung, J., Maeda, M., Chang, A., Bhandari, M., Ashapure, A., & Landivar-Bowles, J. (2021). The potential of remote sensing and artificial intelligence as tools to improve the resilience of agriculture production systems. *Current Opinion in Biotechnology*, *70*, 15–22. https://doi.org/10.1016/j.copbio.2020.09.003
Khan, N., Ray, R. L., Kassem, H. S., Hussain, S., Zhang, S., Khayyam, M., Ihtisham, M., & Asongu, S. A. (2021). Potential role of technology innovation in transformation of sustainable food systems: A review. *Agriculture*, *11*(10), 984. https://doi.org/10.3390/agriculture11100984
Labuschagne, M. (2023). Biofortification to improve food security. *Emerging Topics in Life Sciences*, *7*(2), 219–227. https://doi.org/10.1042/ETLS20230066
Leeuwis, C., Boogaard, B. K., & Atta-Krah, K. (2021). How food systems change (or not): Governance implications for system transformation processes. *Food Security*, *13*, 761–780. https://doi.org/10.1007/s12571-021-01178-4
Meena, V. S., Jat, R. K., Kumar, A., Jha, R. K., Sohane, R. K., Singh, R. N., Durgude, S., Kumar, U., Kumar, A., & Das, A. (2026). Conservation agriculture for climate-resilient agri-food systems: Enhancing productivity, profitability, and sustainability. *Journal of Agriculture and Food Research*, 102765. https://doi.org/10.1016/j.jafr.2026.102765
Menconi, M. E., Stella, G., & Grohmann, D. (2022). Revisiting global food production and consumption patterns by developing resilient food systems for local communities. *Land Use Policy*, *119*, 106210. https://doi.org/10.1016/j.landusepol.2022.106210
Mohammad, Z. H., Ahmad, F., Ibrahim, S. A., & Zaidi, S. (2022). Application of nanotechnology in different aspects of the food industry. *Discover Food*, *2*, 12. https://doi.org/10.1007/s44187-022-00013-9
Monterrosa, E. C., Frongillo, E. A., Drewnowski, A., de Pee, S., & Vandevijvere, S. (2020). Sociocultural influences on food choices and implications for sustainable healthy diets. *Food and Nutrition Bulletin*, *41*(2_suppl), 59S–73S. https://doi.org/10.1177/0379572120975874
Nichols, C. (2020). Nutrition sensitive agriculture: An equity-based analysis from India. *World Development*, *133*, 105004. https://doi.org/10.1016/j.worlddev.2020.105004
Nishad, D. C., Mishra, H., Tiwari, A. K., & Mishra, D. (2024). Post-harvest management: Enhancing food security and sustainability. In *Advances in agriculture science* (Vol. 2, pp. 136–152). Bhumi Publishing.
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https://www.bhumipublishing.com/wp-content/uploads/2024/03/Advances-in-Agriculture-Science-Volume-II.pdf

Odoms-Young, A., Brown, A. G. M., Agurs-Collins, T., & Glanz, K. (2024). Food insecurity, neighborhood food environment, and health disparities: State of the science, research gaps and opportunities. *American Journal of Clinical Nutrition*, *119*(4), 850–861. https://doi.org/10.1016/j.ajcnut.2023.12.019

Ofori, K. F., Antoniello, S., English, M. M., & Aryee, A. N. A. (2022). Improving nutrition through biofortification–A systematic review. *Frontiers in Nutrition*, *9*, 1043655. https://doi.org/10.3389/fnut.2022.1043655

Riely, F., Mock, N., Cogill, B., Bailey, L., & Kenefick, E. (1999). *Food security indicators and framework for use in the monitoring and evaluation of food aid programs*. Food and Nutrition Technical Assistance Project (FANTA). https://socialprotection.gov.bd/wp-content/uploads/2017/06/USAID-Food-Security-Indicators.pdf

Rimhanen, K., Aakkula, J., Aro, K., & Rikkonen, P. (2023). The elements of resilience in the food system and means to enhance the stability of the food supply. *Environment Systems and Decisions*, *43*, 143–160. https://doi.org/10.1007/s10669-022-09889-5

Sekaran, U., Lai, L., Ussiri, D. A. N., Kumar, S., & Clay, S. (2021). Role of integrated crop-livestock systems in improving agriculture production and addressing food security–A review. *Journal of Agriculture and Food Research*, *5*, 100190. https://doi.org/10.1016/j.jafr.2021.100190

Siegner, A., Sowerwine, J., & Acey, C. (2018). Does urban agriculture improve food security? Examining the nexus of food access and distribution of urban produced foods in the United States: A systematic review. *Sustainability*, *10*(9), 2988. https://doi.org/10.3390/su10092988

Simelane, K. S., & Worth, S. (2020). Food and nutrition security theory. *Food and Nutrition Bulletin*, *41*(3), 367–379. https://doi.org/10.1177/0379572120925341

Smith, V. H., & Glauber, J. W. (2020). Trade, policy, and food security. *Agricultural Economics*, *51*(1), 159–171. https://doi.org/10.1111/agec.12547

Vo, T. T. E., Ko, H., Huh, J.-H., & Kim, Y. (2021). Overview of smart aquaculture system: Focusing on applications of machine learning and computer vision. *Electronics*, *10*(22), 2882. https://doi.org/10.3390/electronics10222882

Walsh, F., Zhenchuk, A., Luthringer, C., Kratz, C., & Schweigert, F. (2025). How big data analytics can strengthen large-scale food fortification and biofortification decision-making: A scoping review. *Annals of the New York Academy of Sciences*, *1552*(1), 78–93. https://doi.org/10.1111/nyas.70028

Wang, Y., Zhao, L., Gao, L., Pan, A., & Xue, H. (2021). Health policy and public health implications of obesity in China. *The Lancet Diabetes & Endocrinology*, *9*(7), 446–461. https://doi.org/10.1016/S2213-8587(21)00118-2

Weffort, V. R. S., & Lamounier, J. A. (2024). Hidden hunger–A narrative review. *Jornal de Pediatria*, *100*(Suppl. 1), S10–S17. https://doi.org/10.1016/j.jped.2023.08.009

Wijerathna-Yapa, A., & Pathirana, R. (2022). Sustainable agro-food systems for addressing climate change and food security. *Agriculture*, *12*(10), 1554. https://doi.org/10.3390/agriculture12101554

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CHAPTER 04

Institutional Failures and Reform Pathways: Addressing the Governance Deficit in Food Security Policy

Shoaib Akhtar[1,*], Muhammad Asad ur Rehman Naseer[1], Ashir Kamal[1] & Maryam Nawaz[1]
[1]Department of Agricultural Business and Marketing, Bahauddin Zakariya University, Multan, Pakistan
Corresponding author's email: shoaibakhtar@bzu.edu.pk

Abstract

Pakistan faces a paradox typical of most developing economies of a nation that has significant agriculture resources and a population traditionally dependent on agriculture, and yet, food insecurity has become entrenched in the system and is being reproduced by institutions. In 2024, Pakistan is ranked at 109th position out of 127 countries on the Global Hunger Index, where 36.9 per cent of the population is facing moderate or severe food insecurity and 82 per cent are unable to afford a healthy diet. This chapter contends that this crisis is not just limited to lack of resources or deficit in food production but is due to the cumulative failure of food security governance, overlapping constitutional mandates after 18th constitutional amendment, deep-rooted corruption in procurement institutions like Pakistan Agricultural Storage and Services Corporation (PASSCO), chronic under investment in agricultural research and development, and the persistent failure to translate policy design into implementation. The chapter constructs a typology of institutional failure in four dimensions (design, coordination, accountability and adaptation) based on comparative evidence from Bangladesh, India, Brazil and Ethiopia and then outlines a multi-horizon reform pathway that is structured around Pakistan's political economy. The analysis proposes that durable food security in developing countries is an institutional accomplishment, and that, without ongoing governance reform, technical and financial interventions have limited lasting impact with each successive intervention having a smaller effect.

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1. Introduction: The Governance Paradox in Food Security

Food security as defined by its four cornerstones of availability, access, utilization, and stability (FAO, 2006) is much more of a political and institutional than an agronomic issue. In the developing world, governments have committed to ambitious food security agendas, signed international agreements such as Sustainable Development Goal 2 (Zero Hunger) and invested heavily in agricultural and nutrition initiatives. But there is a worrying disconnect between policy aspirations and policy impacts. This gap is not coincidental but is structurally created and reinforced by governance shortcomings on all levels of the food system in countries with weak institutional environments.

Pakistan is a great example of such a paradox. It has one of the best lands for agriculture in Asia, an ancient system of irrigation based on the Indus River Basin, and a farming community that in the past ensured self-sufficiency in cereals. Despite these assets, Pakistan in 2024 is ranked 109th out of 127 countries according to Global Hunger Index (WFP, 2024) which was 88th in 2020. Almost half of the average household monthly spending is on food, while 82 percent of the population is unable to access food that is nutritionally adequate (WFP, 2024). The Integrated Food Security Phase Classification (IPC) estimated that 11.8 million people in the country's three most vulnerable provinces (Sindh, Balochistan, and Khyber Pakhtunkhwa) would be in Phase 4 acute food insecurity from November 2023 to January 2024 (IPC, 2024).

The prevailing narratives highlight climate shocks such as the 2022 floods displacing millions of people and wiping out standing crops, macroeconomic turmoil as the food price inflation stood at 38.2 percent on average in 2023, and a population that grows faster than the agricultural sector's productivity. All of these

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explanations have some merit, but they are inadequate. They do not explain why neighboring Bangladesh, which has even fewer natural resources, a higher concentration of people and similar levels of climate change exposure, has seen stunting levels drop sharply over the same period, or why Brazil, once considered a country with endemic hunger, has off its hunger map by 2014. The gap is not so much in the agronomy but in governance.

This chapter provides a systematic analysis of the failure of the food security architecture in Pakistan and, in keeping with the theme of policy reform in the rest of the book, conceals actionable directions for institutional change. The analysis is organized into five substantive parts: a theoretical perspective on the nature of institutional failures, an empirical account of the Pakistani governance deficits, a comparative survey of institutional reform experiences in selected developing countries, a critical look at the political economy constraints and a structured roadmap of institutional reform.

2. Theoretical Framework: Institutional Failures in Food Security Governance

Building on the pioneering work by North (1990) and the extensive work by Acemoglu and Robinson (2012), the institutional economics literature has strengthened the case that the rules of the game that shape economic and social life (formal rules, regulatory institutions, procurement regimes) can shape whether individuals or organizations have incentive to promote or undermine the collective welfare. Extrapolated to food security, this tradition implies that hunger is seldom a result of absolute food shortages, but instead of the way in which food is produced, stored and distributed by institutional arrangements, as well as from the absence of or failure to invest in productive activities. Taking this starting point, this chapter uses a typology of four different types of institutional failure that can be discerned at the level of food security systems in developing economies:

2.1. Design Failure

Policies and institutional mandates are poorly drafted, are sometimes contradictory, lack clear authority or are difficult to implement. The food governance system in Pakistan after 18th Amendment is also a design failure as the federal government is keeping 26 out of 39 food ministry functions while ostensibly devolved the food sector to provinces.

2.2. Coordination Failure

More than one institution may have overlapped or competing mandates and not coordinate, resulting in disjointed policy and duplication of efforts. It can be seen as the kind of failure that occurred in the case of cotton, where the responsibility for the policy is split between the textile ministry, fisheries under Ports and Shipping and food safety among various regulatory bodies.

2.3. Accountability Failure

Lack of effective monitoring and control systems can result in rent-seeking, corruption and elite capture undermining the goal of food security. The case of PASSCO procurement scandals, as described in Section 3 below, is a long case of accountability failure.

2.4. Adaptive Failure

Institutions are unable to make the organizational, data or political changes required to adapt the policy to suit the new conditions, be climate change shocks, commodity price fluctuations, or changing nutritional requirements. In Pakistan, R&D Investment in agriculture has been continuously declining, which is a kind of adaptive failure of a particular long-term consequence.

This typology is consistent with the broader literature on state capacity in the Global South (Evans, 1995; Besley & Persson, 2011) and fits with the Pressure-State-Response-Impact (PSRI) framework adapted by the recent food security scholarship that states institutional and governance factors, including corruption, as key structural pressures on food systems. Unlike technocratic strategies for food security reform, it sees governance itself as the target of intervention, rather just a facilitating factor in agricultural development.

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3. Pakistan's Institutional Landscape: Anatomy of a Governance Deficit

Pakistan's food security governance architecture is the product of layered historical decisions, constitutional reforms, and political compromises that have, in aggregate, produced precisely the conditions that the typology in Section 2 identifies as conducive to food insecurity. The following sub-sections examine each failure mode as manifested in Pakistan's institutional landscape.

The 18th Constitutional Amendment, which was passed unanimously by the parliament in April 2010, was one of the greatest structural changes in the history of Pakistan since its independence in 1947. It transferred 17 key federal subjects such as education, health and, in theory, food and agriculture to the provinces. The architects of the amendment wanted to overcome decades of over-centralization and revive the subsidiarity principle in Pakistan's governance system (Rana, 2020).

But there was a design error in devolution of food and agriculture that was built into it from the start. Later when MNFS&R was re-established, the federal government kept 26 out of the 39 functions of the previous Ministry of Food, Agriculture, and Livestock, and delegated 11 to the provinces (Business Recorder, 2026). This resulted in a partial devolution that left an institutional gap with accountability being weakened and not mentally redistributed. The federal government had the words (food security) but the provincial governments had the responsibility (service delivery), without the financial or technical means.

This outcome was inevitable. Agricultural policy became disjointed and spread between institutional boundaries, which were not necessarily aligned with the functional reality of food systems. The functions of the Cotton regulation shifted to the Ministry of Textile Industry while the fisheries continued to be under Ports and Shipping; the food safety functions moved from one department to another and finally came under one National Agri-Trade and Food Safety Authority (NAFSA), which has also been criticized for having overlapping mandates, inadequate scientific and technical capability, and unclear operational authority (Business Recorder, 2026). According to the Pakistan Business Forum (PBF), in May 2026, policy fragmentation and the lack of a cohesive national agricultural strategy may have contributed to the fallout as cotton production dropped to around five million bales, down from around 12 million bales before the amendment.

Agricultural performance for the decade of the 2010s was also found to be the lowest in the last few decades of Pakistan in terms of agricultural growth rate at 2.2 percent due to the fluctuating performance of major crops (Business Recorder, 2020). This is no accident: it's the natural result of a failure of design at the constitutional level and a coordination failure in implementation.

3.1. PASSCO and the Accountability Failure in Procurement

There is no better example of Pakistan's lack of accountability in food governance than the Pakistan Agricultural Storage and Services Corporation (PASSCO). PASSCO was set up in 1973 to purchase wheat from farmers at the price fixed by Government called Minimum Support Price (MSP), and to hold strategic stocks from which to sell to the deficit Provinces and Armed Forces. As late as 2022, PASSCO was buying several million metric tonnes of wheat every year and was the key player in Pakistan's food reserve system.

PASSCO has also been a place of institutional failure over and over again. In 2024, the Federal Investigation Agency arrested the corporation's former General Manager after it was found out that wheat was being bought from middlemen instead of directly from farmers, a violation of the MSP's supposed protection of farmers. Intelligence reports in Bahawalnagar revealed that records of all 22 PASSCO centers in the district were not complete and that gunny bags (bardana) were irregularly distributed by seven procurement center in-charges (Dawn, 2024). Complainants claimed that around 80 per cent of the gunny bags allotted to 19 procurement centers in Mailsi were allotted illegally to commission agents, ineligible persons and politically connected middlemen at an illegal rate of Rs. 500 and Rs. 1,000 (The Express Tribune, February 2026). The National Accountability Bureau (NAB) Multan approved an inquiry in August 2024 into the matter after receiving complaints from farmers and later widened its probe to include 58 PASSCO centers in south

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Punjab, where the estimated number of irregularities was found to be over Rs. Profit by Pakistan Today, Feb 2026: 500 million.

The MSP system was supposed to safeguard farmers, but they were systematically cut out of the procurement process. It failed in its original distributional role and was also a means of redistributing agricultural rents upwards towards connected political actors. The government of Pakistan declared in 2025, as part of the requirements of the IMF Extended Fund Facility, that wheat procurement would be terminated and PASSCO would be dissolved (Rural Voice, 2025). This resolution will eliminate a vector of corruption but the distributional impact on smallholder farmers and national food security will need to be carefully managed during the transition period.

3.2. Food Insecurity Statistics: The Data Profile

The key institutional actors in Pakistan's food security system, their mandates and the more common pattern of institutional failures are listed in Table 4.1. This report outlines the main food security and nutrition indicators from 2015 to 2023/24 in Table 4.1.

Table 4.1: Key Institutional Actors in Pakistan's Food Security Architecture

Institution	Mandate	Key Failure	Governance Level
MNFS&R	Food security policy, research coordination	Overlapping mandate post-18th Amendment	Federal
PASSCO	Wheat procurement & strategic reserves	Systemic corruption, middlemen capture	Federal/Provincial
Provincial Agriculture Depts.	Crop production, extension services	Under-resourcing, political patronage	Provincial
NARC / PARC	Agricultural R&D, seed development	R&D underfunding (<0.5% of Ag-GDP)	Federal
BISP / NSER	Social protection, food access	Coverage gaps, targeting inefficiency	Federal
NAFSA	Agri-trade & food safety regulation	Unclear authority, weak capacity	Federal

Sources: Business Recorder (2026); MNFS&R (2023); WFP (2024); FAO *et al*. (2024).

Table 4.2: Pakistan Food Security and Nutrition Indicators, 2015–2024

Indicator	2015	2020	2023/24
Global Hunger Index Rank	93 / 117	88 / 107	109 / 127
Food Insecurity (Mod. or Severe) %	~28%	~31%	36.9%
Stunting (Children <5 yrs) %	45%	40.2%	~38%
Wasting (Children <5 yrs) %	10.5%	17.7%	~18%
Food Price Inflation (Annual Avg.) %	3.2%	14.6%	38.2%
Agric. R&D Spending (% of AgGDP)	0.49%	0.42%	<0.40%
Population without Healthy Diet %	~70%	~75%	82%

Sources: WFP (2024); FAO *et al*. (2024); IPC (2023); Global Hunger Index (2024); National Nutrition Survey (2018); Pakistan Bureau of Statistics (2023); Agri Economist (2025).

The trend identified in Table 4.2 is of a decline in just about every measure. The percentage of the population facing moderate or severe food insecurity in Pakistan has increased from about 31 percent in 2020 to 36.9 percent in 2024, as Pakistan's GHI rank has dropped from 88th place in 2020 to 109th in 2024. After holding in single digits through the mid-2010s, food price inflation has jumped significantly to 38.2 percent on average in 2023, squeezing food access of the most economically vulnerable households (Agri Economist, 2025). Agricultural R&D expenditure, which is already far lower than the regional and global averages, continued to shrink as a share of agricultural GDP, thus limiting the sector's ability to adjust to changing circumstances (Legatum Prosperity Index, 2023).

3.3. Land ownership and agrarian structure and adaptive failure

A second facet of institutional failure that has deep implications on food security in Pakistan is the land tenure system. Despite the fact the farming population occupied around 42 percent of the total rural

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household population in Pakistan, the land ownership is highly concentrated, with a small group of landowners controlling a large share of the agricultural resources while the majority of the farming households are small farmers with land holdings under five hectares or tenant cultivators (Pakistan Bureau of Statistics, 2023). There are several institutional implications of this agricultural system. Second, informal and potentially exploitative contracts between tenants and landlords mean that tenant farmers have weak incentives to invest in soil health, water management, and adoption of better practices, as much of the benefit may accrue to the landowners. Such a distortion of property rights and residual returns is a typical institutional impediment to agricultural intensification (Binswanger-Mkhize *et al*., 1995).

Second, despite the introduction of digital land record systems (LRMIS) in Punjab and other provinces, these are still not fully covered and have been challenged in the courts. Third, smallholders and tailenders in the irrigation hierarchy suffer institutional discrimination in the allocation of water entitlements, which is a direct result of the method of allocation by the provincial irrigation departments based on historical rights that has a direct impact on agricultural productivity and food availability. These structural characteristics of Pakistan's agrarian economy combine with the design and accountability failures mentioned above to create an adaptive capacity deficit, the inability to reconfigure production systems in response to climate shocks, market signals and new nutritional needs. This systemic adaptive failure is witnessed in the serial crises of wheat shortage and surplus and the policy improvisations that ensued.

4. The Developing World: Comparative Perspectives (Reform Experiences).

Systematic comparisons with other developing countries with similar governance shortcomings, and in some instances, significant gains from ongoing institutional reforms, provide further insights into institutional failures in Pakistan. Four comparative cases are discussed in this section: Bangladesh, India, Brazil and Ethiopia.

4.1. Bangladesh: Famine Vulnerability to Nutritional Progress

Given the shared colonial and post-partition history, population density and exposure to climate extremes, perhaps Bangladesh offers the most instructive contrast to Pakistan. In 1971, independence and in 1974, a devastating famine, Bangladesh experienced major institutional breakdown in the Public Food Distribution System (PFDS) in terms of leakage, targeting errors and logistical inefficiency.

Yet, the Bangladeshi reform evolution was different from that of Pakistan, because of continuous investigation on institutions and programmatic innovation. The creation of the Food Planning and Monitoring Unit (FPMU) created an evidence-based policy planning unit which gradually enhanced the targeting and efficiency of food distribution programs. The Vulnerable Group Development (VGD) and Vulnerable Group Feeding (VGF) programs established institutional channels of access to food for the chronically poor (World Bank, 2024). Most important, Bangladesh invested in decentralized implementation structures that could connect with the village level realities as opposed to the centrally run implementation systems which are vulnerable and politically weak in Pakistan. The nutritional results are impressive: In Bangladesh, the rate of child stunting dropped from around 55 per cent in 2000 to 28 per cent in 2019, one of the fastest rates of improvements in nutrition in the developing world (UNICEF, 2016). However, this success was not only economic, as Bangladesh's per capita income is still lower than Pakistan's, but by the effectiveness of the institutions in targeting nutrition interventions to the vulnerable people.

4.2. India: Targeted intervention via Aadhaar-based targeting is not part of the National Food Security Act.

The implementation of food security reform in India provides some lessons learnt and examples to inspire Pakistan. Prior to the reform period, India's Public Distribution System (PDS) was plagued by the problem of massive leakage where estimates placed as high as 40 per cent of food grains being sold subsidized end up being diverted from those they were meant to benefit. It was an example of ‘accountability failure' (systematic corruption in distribution networks) and ‘design failure' (universal rather than targeted coverage).

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The National Food Security Act (NFSA) of 2013 was a design-level intervention which provided legal entitlements for subsidized food grains for about two-thirds of India's population. In terms of institutions, however, more transformative was the progressive integration of the Aadhaar biometric identification system into PDS delivery, allowing electronic point-of-sale authentication which drastically cut impersonation fraud and diversion of rations to ghost beneficiaries. In the early 2020s, estimates indicate that this technological-institutional intervention has decreased leakage to 15 percent as compared to 40 percent in many states, which has allowed fiscal savings that can be used for program expansion.

The National Socio-Economic Registry (NSER) database, which BISP in Pakistan uses, incorporated features of this model and NADRA's biometric capacities hold similar potential for better targeting. The Indian experience shows that institutional reform can lead to significant resource efficiency improvements in the absence of extra spending – a significant political lesson in Pakistan's limited fiscal space.

4.3. Brazil: Fome Zero and the Architecture of Multi-Stakeholder Governance

The shift of Brazil from one of the world's most food insecure countries to one that took itself off the FAO's hunger map by 2014 is considered one of the greatest successes in food security governance in the early twenty-first century. The Fome Zero (Zero Hunger) program, introduced by the Lula government in 2003, was architecturally unique for combining social protection (Bolsa Familia conditional cash transfers), food access (popular restaurants, food banks) and agricultural development (the family farmer procurement programs) in one strategic approach. Most significantly, Fome Zero was accompanied by the formalization of multi-stakeholder governance, in the case of Fome Zero, through the creation of a constitutional multi-stakeholder body the National Food and Nutritional Security Council (CONSEA), which afforded civil society organizations, farmer organizations and nutrition experts a formal role in food policy debate alongside the government ministers (Rocha, 2009). This institutional innovation has solved the problem of many food systems in developing countries and absence of a system of accountability whereby citizens can hold food policy to account.

It has serious consequences for Pakistan. There is nothing like an institutionalized mechanism of CSO participation in food policy in Pakistan. The Ministry of National Food Security and Research works in a more administrative than deliberative manner and formal accountability to agricultural communities (smallholder farmers, pastoralists and nutritionally vulnerable urban households) is weak. CONSEA is a model that can be replicated in Brazil and in other countries to provide an institutional innovation that can correct for the lack of accountability as well as create the political leverage to keep reform on track in the face of resistance from elites.

4.4. Ethiopia: Productive Safety Net Program and Community Based Adaptation

Ethiopia, the most food-insecure country in the world for most of the post-war era, is a partial and illustrative success story in terms of institutional reform. The Productive Safety Net Program (PSNP) was introduced in 2005 with the support of the World Bank, to move away from food aid, which had been the main form of international response to hunger in Ethiopia, to a more predictable and system-based approach to social protection for chronically food-insecure households. PSNP's institutional design was based on the community-based targeting to identify beneficiaries, which was a conscious decision to embed the program in local knowledge and accountability systems not previously used in other top-down programs. As of 2024, the program had reached 8.3 million beneficiaries and was among the largest social protection programs in sub-Saharan Africa (World Bank, 2024). Previous program evaluations have shown improvement in household food security, asset accumulation and nutritional status of children (Berhane *et al*., 2017). Furthermore, sustained political stability is a prerequisite for institutional reform, which, as seen in the case of Ethiopia, can be undermined even by well-designed institutional systems, when a conflict erupted in Tigray in 2020 and climate shocks hit more recently. Building resilience and redundancy into food security governance structures is important, as observed in Pakistan during flooding in 2022.

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5. Political Economy Constraints on Institutional Reform

An analytically sophisticated explanation of institutional failure should not only explore the technical aspects of designing programs and policies, but the political economy of resistance to reform. Food security governance institutional failures are not simply due to a lack of knowledge among policymakers regarding alternative institutional arrangements the comparison of evidence provided in Section 4 is widely available but rather because the current institutional arrangements provide rents for politically powerful actors who can resist institutional change.

5.1. Agrarian Political Economy and Elite Capture.

Pakistan's agrarian political economy has been influenced by a long-standing partnership of big landowners, rural intermediaries and certain other groups of the political and bureaucratic elite that has historically limited the scope of agricultural reform. Feudal or quasi-feudal land holding structure in the provinces of Sindh, southern Punjab and parts of Baluchistan has resulted in the policy of agriculture often being caught up by the landed elite, whose interests are quite different from those of smallholder farmers and landless laborers.

The wheat MSP and PASSCO procurement system, as detailed in Section 3.2, is a prime example of how elite capture works. The nominal design of the system was to give cultivators smallholder producers price guarantees. In practice it was a system whereby politically connected middlemen and commission agents were able to rent off the procurement system, aided by officials at various institutional levels. The Legatum Prosperity Index (2023) ranked Pakistan 136th among 167 countries overall and 118th on governance and these systemic failures in the domain of institutional accountability.

5.2. Civil-Military Relations and Agricultural Policy

The unique institutional landscape of civil-military dynamics in Pakistan has further complicated governance of food security. The significant military involvement in the agricultural sector (via defense authorities, agri-business and land allocation) gives rise to institutional interests that do not necessarily fit with that of the food security policy for the general population. In addition, regular changes of civilian governments and the resulting lack of policy continuity have hindered the longer-term institutional investment needed for effective food security governance.

Political commitment is found in every reform literature as a precondition for institutional changes to be successful (Acemoglu and Robinson, 2012). In those places where political will is limited, hinges on the electoral cycle, and/or prioritizes military-bureaucratic interests, institutional reform is likely to be partial, reversible, and claimed by vested interests before any of its distributional gains can be realized.

5.3. IMF Conditionality and the Reform Paradox

The current IMF extended fund Facility (EFF) agreement under which Pakistan will receive US$7.11 billion from July 2024 to December 2028 provides an additional dimension to the challenge of institutional reforms. The wheat procurement system has been eliminated and PASSCO is slated for disintegration, both on efficiency and fiscal grounds, but with good reasons, since these institutions have been proven to be dysfunctional (Rural Voice, 2025).

But state withdrawal from agricultural markets happens while replacement institutions are not in place, creating a reform paradox: the removal of the nonfunctional institution does not necessarily generate functional institutions. The farmers of south Punjab, already badly served by PASSCO, are now in a period of transition, where nominally they are no longer protected by farmers' price support mechanisms and the private market structures needed to replace them are not yet fully developed. In similar circumstances in the other parts of the developing world, the same dynamic of austerity-induced institutional withdrawal with no institutional replacement has resulted in food security deterioration (Mkandawire & Soludo, 1999).

The challenge of this reform paradox is to think in terms of what the literature in development economics calls 'second-best' institutional thinking: the institutional question is not what is theoretically optimal, but

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what is feasible and sustainable in a country at a particular point in history, given the prevailing political economy context (Rodrik, 2008).

6. Reform Pathways: Toward Governance Architecture for Food Security

Based on the theoretical framework presented in Section 2, the empirical analysis of the governance deficit in Pakistan presented in Section 3, and the comparative empirical evidence synthesized in Section 4, a structured multi-horizon reform agenda is presented in this section. The reform roadmap has been structured around three horizons: immediate (0-2 years), medium-term (2-5 years) and long-term (5-10 years) and is based on the political economy constraints identified in Section 5.

6.1. Immediate-Term Reforms: Coordination and Accountability

The most pressing institutional need of Pakistan is the creation of a National Food Security Council (NFSC) with a well-defined inter-ministerial coordination mandate, statutory authority and secretarial independence from MNFS&R. It is recommended that the Council convene the federal and provincial agriculture secretaries, the Finance Division, BISP and civil society representatives in a regularized deliberative forum, similar to the CONSEA in Brazil. It should be empowered to review the PSDP allocations of federal government to food and agriculture on an annual basis on the basis of evidence, produce an annual National Food Security Assessment, and have the authority to recommend PSDP allocations.

At the same time, market-based trading of grain should replace PASSCO-mediated procurement, with a fast and large-scale roll-out of digital safety net mechanisms. The coverage of BISP, which currently reaches around 9.3 million households, should be extended by taking advantage of the NSER data and the NADRA's biometric verification system – the very system that was successfully applied in the PDS reform in India. BISP transfers should consist of a food specific component linked to the price of a nutritionally adequate food basket, thus offering a price-indexed food entitlement, conditional on satisfactory targeting data.

6.2. Medium-Term Reforms: Agricultural R&D, Land Tenure and Nutritional Governance

One of the most significant adaptive failures in the food security system is the chronic under-investment in Pakistan's AgR&D system, which spent less than 0.4 percent of AgGDP, as compared with the recommended level of 1 percent and the developing country average of 0.5 percent (IFPRI, 2022). PARC's institutional mandate needs to be redefined, specifically for climate resistant variety development, soil health management in smallholder settings and water use efficient technologies.

Land tenure reform is politically controversial but is essential for sustainable enhancement of agricultural productivity and food security of smallholders and tenant cultivators. Completing the nationwide Land Records Management and Information System (LRMIS), which is already working in Punjab, is to be seen as an investment in food security and not only as an administrative exercise. A formalizing of the sharecropping contracts, as advocated by Binswanger-Mkhize *et al*. (1995) for similar situations, would start to overcome incentives to under-invest in Pakistan's informal tenancy system.

The nutritional governance system in Pakistan should be strengthened with the establishment of a dedicated National Nutrition Authority with cross-ministerial coordination authority, institutionalizing School Nutrition Program and increasing the mandate of LHP's nutritional counselling. The Lady Health Visitor program in Bangladesh has proved through its experience that health and nutrition workers in the community, working under an institutionalized referral mechanism, can improve child nutritional outcomes in a low resource setting to a great extent.

6.3. Constitutional clarity and climate-smart systems are the two key focus areas for long-term reforms.

If Pakistan's food security structure needs to be sustained in the longer term, the confusion caused by the 18th amendment needs to be addressed. This does not have to imply a re-centralization of the food and agriculture policy, with the principle of provincial autonomy maintaining its constitutional legitimacy and practical value for responsive service delivery. Instead, it demands a clear constitutional settlement in which

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the roles of federal and provincial governments in food security governance are negotiated; there are enforceable inter-governmental cooperation obligations; and a formula for federal and provincial allocation of fiscal resources to agricultural investment that matches provincial mandates.

Climate change is structurally distinct from the governance challenges outlined in previous sections and is a qualitative threat to Pakistan's food security: it cannot be addressed merely by institutional reform but can be significantly mitigated by institutional adaptation. Pakistan's vulnerability to climate change and its ranking as the eighth most climate-vulnerable country in the world (WFP, 2024; Khan *et al*., 2024) necessitates embedding climate-smart agriculture (CSA) principles across the institutional framework of food production, at all levels. This has involved integrating climate adaptation goals into PARC's research program; requiring the Agricultural Departments of the provinces to mainstream climate adaptation extension approaches; and setting up a Climate and Food Security Early Warning System based on the IPC methodology developed through Pakistan's partnership with FAO and WFP.

Table 4.3: Multi-Horizon Reform Pathway for Pakistan's Food Security Governance

Time Horizon	Priority Reform	Lead Institution	Expected Outcome
Immediate (0–2 yrs)	Establish National Food Security Council; mandate inter-ministerial coordination	PM Secretariat / MNFS&R	Reduce federal-provincial policy gaps; single policy framework
Immediate (0–2 yrs)	Digitize procurement & safety nets (BISP expansion, e-targeting)	BISP, ECP, NADRA	Reduce leakage; improve beneficiary targeting accuracy
Medium-term (2–5 yrs)	Reform land tenure; operationalize land record digitization nationwide	Provincial govts. + World Bank support	Smallholder investment security; reduced tenancy exploitation
Medium-term (2–5 yrs)	Raise agricultural R&D to 1% of AgGDP; strengthen PARC mandate	PARC, HEC, MNFS&R	Climate-resilient varieties; productivity gains for smallholders
Long-term (5–10 yrs)	Implement constitutional clarity on food governance (post-18th Amend. rationalization)	Parliament, NFC Commission	Eliminate overlapping mandates; clear accountability chains
Long-term (5–10 yrs)	Scale climate-smart agriculture (CSA); integrate food systems approach	MNFS&R, FAO, WFP	Improved GHI ranking; SDG 2 progress by 2035

Author's synthesis drawing on World Bank (2024), IFPRI (2022), FAO *et al*. (2024), and comparative case evidence.

7. Conclusion

The chapter demonstrates that Pakistan’s food insecurity crisis is fundamentally a governance crisis rather than merely a production or resource problem. While the country possesses considerable agricultural potential, institutional fragmentation, overlapping constitutional mandates, weak accountability mechanisms, corruption in procurement systems, inadequate investment in agricultural research, and limited adaptive capacity have collectively undermined the effectiveness of food security policies. Comparative experiences from Bangladesh, India, Brazil, and Ethiopia illustrate that sustained institutional reforms, evidence-based policymaking, and inclusive governance structures can significantly improve food security outcomes even under resource constraints. The analysis further highlights that technical interventions and financial investments alone cannot generate lasting progress unless they are supported by transparent, coordinated, and accountable institutions. Moving forward, Pakistan requires a phased reform agenda that strengthens federal-provincial coordination, modernizes social protection and procurement systems, expands agricultural research and innovation, clarifies constitutional responsibilities, and mainstreams climate-smart and nutrition-sensitive policies. Ultimately, achieving sustainable food security and meeting SDG 2 will depend on the country’s ability to transform its governance architecture into one that is adaptive, participatory, and resilient. Durable food security is not simply the outcome of higher agricultural output; it is the product of institutions capable of translating resources into equitable, efficient, and inclusive development.

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References

Acemoglu, D., & Robinson, J. A. (2012). *Why nations fail: The origins of power, prosperity, and poverty*. Crown Publishers.

Agri Economist. (2025). *Food security challenges in Pakistan: Urgent solutions*. The Agricultural Economist. https://www.agrieconomist.com/food-security-challenges-in-pakistan-urgent-solutions

Berhane, G., Hoddinott, J. & Kumar, N. (2017). *The impact of Ethiopia's Productive Safety Net Programme on the nutritional status of children: 2008–2012*. International Food Policy Research Institute, Washington DC, USA. https://cgspace.cgiar.org/server/api/core/bitstreams/00fafdc8-c1bf-45bc-b764-273e41471fcc/content

Besley, T., & Persson, T. (2011). *Pillars of prosperity: The political economics of development clusters*. Princeton University Press. https://doi.org/10.1515/9781400840526

Binswanger-Mkhize, H. P., Bourguignon, C., & van den Brink, R. (Eds.). (1995). *Power, distortions, revolt, and reform in agricultural land relations*. World Bank. https://ideas.repec.org/h/eee/devchp/4-42.html

Business Recorder. (2020). *Understanding agriculture's constitutional arrangement*. https://www.brecorder.com/news/561266

Business Recorder. (2026, February 25). *Why Pakistan punishes its farmers*. https://www.brecorder.com/news/40408642/why-pakistan-punishes-its-farmers

Dawn. (2024, June 3). *Corruption in wheat procurement: PASSCO centre in-charges pass the buck to high-ups*. https://www.dawn.com/news/1834131

Evans, P. (1995). *Embedded autonomy: States and industrial transformation*. Princeton University Press.

FAO. (2006). *Food security* (Policy Brief No. 2). Food and Agriculture Organization of the United Nations.

FAO, IFAD, UNICEF, WFP, & WHO. (2024). *The state of food security and nutrition in the world 2024*. FAO. https://openknowledge.fao.org/handle/20.500.14283/cd1254en

Global Hunger Index. (2024). *2024 Global Hunger Index: How gender justice can advance climate resilience and zero hunger*. Welthungerhilfe & Concern Worldwide. https://www.globalhungerindex.org/pdf/en/2024.pdf

IFPRI. (2022). *Global food policy report: Transforming food systems after COVID-19*. International Food Policy Research Institute.

IPC. (2023). *Pakistan: Acute food insecurity situation for April–October 2023 and projection for November 2023–January 2024*. Integrated Food Security Phase Classification. https://www.ipcinfo.org/

IPC. (2024). *Pakistan: Acute food insecurity situation November 2024–July 2025*. Integrated Food Security Phase Classification. https://www.ipcinfo.org/

Khan, Y., Bojnec, Š., Daraz, U., & Zulpiqar, F. (2024). Exploring the nexus between poor governance and household food security. *Economic Change and Restructuring, 57*(2), Article 92. https://doi.org/10.1007/s10644-024-09679-w

Legatum Prosperity Index. (2023). *Pakistan country rankings*. Legatum Institute. https://index.prosperity.com/globe/pakistan

Mkandawire, T., & Soludo, C. (1999). *Our continent, our future: African perspectives on structural adjustment*. Council for the Development of Social Science Research in Africa.

National Nutrition Survey. (2018). *National Nutrition Survey 2018: Key findings report*. Government of Pakistan, Ministry of National Health Services, Regulations and Coordination, & UNICEF Pakistan. https://www.unicef.org/pakistan/reports/national-nutrition-survey-2018-key-findings-report

North, D. C. (1990). *Institutions, institutional change, and economic performance*. Cambridge University Press.

Pakistan Bureau of Statistics. (2023). *Pakistan Social and Living Standards Measurement Survey 2022–23*. Government of Pakistan. https://www.pbs.gov.pk/pslm-3/

Profit by Pakistan Today. (2026, February 19). *NAB probes Rs 500 million corruption in wheat procurement*. https://profit.pakistantoday.com.pk/2026/02/19

Rana, M. A. (2020). Decentralization experience in Pakistan: The 18th Constitutional Amendment. *Public Administration and Development, 40*(1), 22–31. https://doi.org/10.1177/0972820119892720

Rocha, C. (2009). Developments in national policies for food and nutrition security in Brazil. *Development Policy Review, 27*(1), 51–66. https://doi.org/10.1111/j.1467-7679.2009.00435.x

Rodrik, D. (2008). Second-best institutions. *American Economic Review, 98*(2), 100–104.

Rural Voice. (2025). *Under IMF pressure, Pakistan ends wheat procurement and MSP system*. https://eng.ruralvoice.in/international

The Express Tribune. (2026). *1.07m wheat bags under investigation in PASSCO case*. https://tribune.com.pk/story/2593342

UNICEF. (2016). *Nutritional status of children in Bangladesh*. UNICEF Bangladesh. https://www.unicef.org/bangladesh/en/nutrition

WFP. (2024). *Pakistan country brief*. World Food Programme. https://www.wfp.org/countries/pakistan

World Bank. (2024). *Ethiopia Productive Safety Net Programme overview*. World Bank Group. https://documents.worldbank.org/pt/publication/documents-reports/documentdetail/893931468321850632

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CHAPTER 05

Decentralization And Local Food Governance: A Multilevel Framework with Comparative Evidence from Selected Developing Economies

Amar Razaq[1,*], Muhammad Asad ur Rehman Naseer[2], Muhammad Shoaib Naseer[3] & Saher Jabeen[4]
[1] Business School, Huanggang Normal University, Huanggang, China
[2] Department of Agribusiness & Marketing, Bahauddin Zakariya University Multan, Pakistan
[3] Agriculture Marketing, Government of Punjab, Pakistan
[4] Harbin Institute of Technology, Harbin, Heilongjiang, China
Corresponding author's email: amar.razzaq@hotmail.com

Abstract

Decentralization has become one of the main governance reforms through which developing economies try to make food security policy more responsive to local conditions. The reform promise is straightforward: subnational governments and community institutions may know local agroecological conditions, household vulnerability, market constraints, and social exclusion better than central ministries. Yet decentralization can also reproduce weak service delivery when authority is transferred without finance, staff, data systems, accountability, or coordination. This chapter argues that local food governance should be assessed as a design problem rather than as a general reform ideal. Effective devolution links clear functional assignments, predictable finance, capable local administration, public participation, and national standards. The chapter develops a multilevel framework for food governance, compares fiscal and institutional patterns in selected developing economies, and uses case boxes from Pakistan, India, Brazil, Kenya, Indonesia, and Ethiopia. It concludes that decentralized governance can strengthen inclusion and responsiveness, but only when local discretion is embedded in transparent institutions and coherent intergovernmental systems.

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1. Introduction

Food security policy in developing economies is increasingly a question of governance. National governments still set the broad legal and fiscal architecture for agriculture, nutrition, trade, safety nets, public procurement, and food quality. However, many of the decisions that determine whether those policies reach households are made closer to the ground: district officers classify beneficiaries, extension workers advise farmers, municipal authorities manage markets, school committees monitor meals, local councils allocate small infrastructure budgets, and community organizations decide whether the poorest households are heard. The apparent simplicity of the decentralization idea masks a difficult institutional task. Local food governance must connect national commitments with local delivery without creating fragmented authority, fiscal stress, or exclusion.

The analytical point of departure for this chapter is that decentralization is neither a cure for state failure nor a cause of failure by itself. It is a set of institutional arrangements that changes who has authority, who pays, who implements, who monitors, and who can make claims on the state. Fiscal federalism theory suggests that locally tailored public goods may be supplied more effectively when local governments have information about preferences and costs (Oates, 1972, 1999; Tiebout, 1956). Public administration and political economy research, however, warns that local institutions can be captured by elites, starved of funds, or forced to implement centrally designed programs without real discretion (Bardhan & Mookherjee, 2006; Mansuri & Rao, 2013; World Bank, 2003). Food security makes these tensions sharper because food policy involves production, purchasing power, nutrition, public health, gender relations, land, water, markets, climate risk, and social protection.

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The chapter develops a governance framework for judging when and how decentralization can improve food security results. The argument has four parts. First, decentralization can strengthen local responsiveness when authority is matched with finance and administrative capacity. Second, participation improves policy only when communities can influence priorities and hold officials to account, not when participation is limited to consultation. Third, local food governance needs national coordination because food markets, price shocks, climate hazards, and nutrition standards cross local boundaries. Fourth, decentralized reform should be assessed through its effects on inclusion, service quality, resilience, and rights-based access, not only through formal legal transfer of powers.

The chapter proceeds as follows. Section 2 defines decentralization and local food governance. Section 3 develops a conceptual framework linking devolution to food security results. Section 4 examines key policy domains in which local governance matters. Section 5 discusses risks and design safeguards. Section 6 presents comparative evidence from selected countries. Section 7 draws policy lessons for governments and development partners. The chapter uses tables and figures as original synthesis tools, while one figure uses reproducible subnational finance data from the World Observatory on Subnational Government Finance and Investment.

2. Concepts: decentralization and local food governance

Decentralization refers to the transfer of authority, resources, responsibilities, or political decision-making from central government to subnational units. The receiving units may be elected provincial, state, district, county, municipal, village, or community institutions. The literature distinguishes among administrative decentralization, fiscal decentralization, political decentralization, and deconcentration. The distinction is important because a reform that moves staff to districts but leaves budget control in the capital is different from a reform that gives elected local governments authority over budget priorities. Decentralization can also occur inside line ministries through field offices, or outside line ministries through autonomous local governments.

Table 5.1. Forms of Decentralization and Food Governance Implications

Form	Core meaning	Food governance examples	Main caution
Administrative decentralization	Transfer of implementation tasks, staff, or field operations to subnational offices.	Extension services, disease surveillance, market inspection, nutrition outreach.	May improve reach, but local offices may still lack discretion over priorities or budgets.
Fiscal decentralization	Transfer of revenue powers, expenditure responsibilities, grants, borrowing rules, or fiscal discretion.	District food-security plans, feeder roads, storage, local procurement, municipal markets.	Unfunded mandates can weaken delivery and create blame shifting.
Political decentralization	Authority of elected subnational governments and councils to set priorities and answer to citizens.	County agriculture budgets, local food councils, public hearings, school meal oversight.	Accountability depends on credible elections, information, and inclusion of marginalized groups.
Functional decentralization	Assignment of specific food system functions to the level best suited to deliver them.	National food standards, provincial procurement, district targeting, village grievance systems.	Poor assignment creates overlaps, gaps, and conflict across levels.
Deconcentration	Central ministries place staff in local offices but retain policy and finance control.	Local field officers implement national programs.	Useful for administrative reach, but weak for local priority setting.

Note. Prepared by the authors from fiscal federalism, service-delivery, and participation literature, including Oates (1972, 1999), Ahmad *et al*. (2005), Faguet (2014), and Mansuri and Rao (2013).

Local food governance refers to the rules, organizations, financing arrangements, and participation mechanisms through which local actors shape food availability, access, utilization, stability, agency, and sustainability. This definition extends the conventional four-pillar food security framework by incorporating agency and sustainability, following the High-Level Panel of Experts on Food Security and Nutrition (HLPE, 2020). In practice, local food governance includes district agricultural plans, local procurement, market management, land and water governance, school meals, local health and nutrition platforms, disaster

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preparedness, and community feedback systems. The scope is wider than agriculture because food security is not produced by farms alone.

The policy relevance of Table 5.1 is that each form of decentralization answers a different question. Administrative decentralization asks where state employees work. Fiscal decentralization asks who pays and who can reallocate resources. Political decentralization asks who decides and who is answerable to citizens. Functional decentralization asks which level of government should carry each responsibility. Good food governance requires all four questions to be answered together. A district cannot deliver nutrition services when it controls neither staff nor funds. A municipality cannot regulate food markets when it lacks legal authority over market committees. A village committee cannot monitor school feeding when meal budgets, menus, and supplier selection are opaque.

Table 5.2. Assignment of Food Security Functions Across Levels of Government

Level	Functions suited to that level	Reason for assignment
National	Food rights, national food reserves, trade policy, food quality and safety standards, macro-fiscal rules, national data architecture.	Cross-border price shocks, national equity standards, and large safety-net financing require central coordination.
Provincial or state	Program adaptation, co-financing, procurement systems, extension systems, regional climate and water plans, supervision of districts.	This level often has the scale to manage staff systems and procurement while still adapting to agroecological zones.
District or county	Integrated food-security plans, local targeting, nutrition coordination, market infrastructure, early warning, public works planning.	Districts and counties can coordinate agriculture, health, roads, markets, and welfare more directly.
Municipal or village	Market sanitation, local roads, storage sites, fair-price shop oversight, school meal committees, grievance intake, beneficiary verification.	Frontline bodies can identify exclusion and leakage but require safeguards against capture.
Community organizations	Farmer groups, women groups, social audits, water user associations, local food councils, producer cooperatives.	Community institutions generate local knowledge and scrutiny but need inclusive design and protection from elite control.

Note. Prepared by the authors. The allocation follows subsidiarity, scale economies, externalities, and rights-based accountability principles.

Figure 5.1. Conceptual Framework Linking Decentralization to Food Security Results

Note. Prepared by the authors. The figure treats fiscal transfers, authority, capacity, participation, accountability, and intergovernmental coordination as joint conditions.

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3. Why decentralization can improve food governance

The strongest argument for decentralized food governance is informational. Food insecurity is local in its lived form even when its drivers are national or global. In one district, hunger may reflect drought and livestock disease. In another, it may reflect landlessness, debt, or the seasonal absence of wage work. In a city, the binding constraint may be food price inflation, unsafe markets, poor transport, or rental costs that crowd out food spending. Central ministries rarely observe these conditions with enough speed or detail. Local institutions can convert proximity into better targeting and program adaptation when they have authority to act.

Responsiveness also matters because food insecurity can change quickly. Floods, droughts, pest outbreaks, conflict, fuel-price shocks, and local market disruptions can alter household food access within weeks. Local governments and community institutions can support early warning through market price reporting, crop condition monitoring, nutrition screening, and grievance signals. When this information is connected to pre-agreed financing and program triggers, decentralized systems can shorten the distance between signal and response. Without those triggers, local observation may simply create a record of distress that no one is funded to address.

Participation is a second potential advantage. Local food governance can create spaces where smallholders, tenant farmers, pastoralists, fishers, women, traders, landless laborers, consumers, and nutrition workers shape priorities. This matters because food policy often favors visible production targets and politically organized producer groups, while the food access needs of women, migrants, informal workers, and remote households receive less attention. Participatory budgeting, school meal committees, food councils, social audits, and public hearings can widen the agenda. Yet participation must be judged by influence, not attendance. Mansuri and Rao (2013) show that induced participation has mixed performance and depends heavily on context, facilitation, and learning-by-doing.

Table 5.3. Opportunities and Risks of Local Food Governance

Opportunity	Food-security value	Governance risk	Design safeguard
Local information	Better recognition of seasonal hunger, livelihood risks, prices, and social exclusion.	Information can be manipulated by local elites.	Public criteria, transparent beneficiary lists, appeal channels, and third-party checks.
Participation	Local actors can influence planning, procurement, school meals, and market priorities.	Participation may become symbolic or dominated by powerful groups.	Representative rules, women-led spaces, independent facilitation, and feedback reports.
Responsiveness	Local authorities can respond faster to shocks and market disruption.	No response occurs if authority is devolved without funds or contingency rules.	Emergency grants, shock triggers, and local contingency plans.
Service integration	Agriculture, health, nutrition, roads, water, and welfare can be coordinated locally.	Mandate overlap may create confusion and delay.	Joint planning committees and clear functional assignment.
Accountability	Citizens can monitor nearby providers, shops, markets, and committees.	Local politics can protect poor performers.	Social audits, open contracting, scorecards, and independent grievance redress.

Note. Prepared by the authors from Faguet (2014), Bardhan and Mookherjee (2006), Mansuri and Rao (2013), and the World Development Report 2004 (World Bank, 2003).

Accountability is the third argument. When beneficiaries know who is responsible for delivery, and when they can complain, vote, organize, or audit, local institutions may reduce leakage and improve service quality. Bardhan and Mookherjee (2006) argue that the accountability advantage of decentralization depends on the balance between better local information and greater risk of local elite capture. The same logic applies to food governance. A local committee may know which households are hungry, but it may also favor relatives, caste networks, party supporters, large farmers, or better-connected traders. The institutional design question is how to preserve local information while constraining local favoritism.

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A fourth advantage is policy integration. Food security problems rarely fit one ministry. A malnourished child may need household income support, maternal health care, clean water, affordable diverse foods, and reliable local transport. A climate-stressed farming household may need water management, extension, insurance, market access, public works, and a safety net during the lean season. District or county planning can combine these functions more easily than vertically organized national departments, provided it has authority over local coordination and access to timely data.

4. Main policy domains for decentralized food governance

Decentralization has the greatest food-security relevance where local knowledge, repeated contact with beneficiaries, or coordination across sectors is important. The following domains are especially suited to subnational roles, though not all functions should be fully devolved.

4.1. Extension, advisory services, and farmer support

Extension is a natural site for decentralization because crop choices, water constraints, pest pressures, seed suitability, livestock systems, and social barriers differ by place. Local extension officers can tailor advice and connect farmers with inputs, credit, climate information, and markets. Yet extension is prone to uneven quality when local governments lack technical staff or when recruitment is politicized. National and provincial systems should retain standards for training, professional certification, data reporting, and research-extension linkages. Local discretion should focus on prioritizing needs, farmer group engagement, and delivery adaptation.

4.2. Local procurement, school feeding, and short supply chains

Public procurement can connect food access with local farm income. School feeding, hospitals, and public institutions can buy from smallholders and cooperatives when procurement rules are designed for scale-appropriate suppliers. Brazil's National School Feeding Program offers a widely cited example because Law No. 11,947 established a minimum share of federal school feeding resources for direct purchase from family farming (Sidaner *et al*., 2013; Silva *et al*., 2023). The lesson is not that every country should copy Brazil, but that local procurement works best when national rules, municipal implementation, nutrition standards, farmer organization, and social oversight are joined.

Box 5.1 Brazil: school feeding, family farming, and municipal implementation

Brazil's PNAE shows how a national framework can create local food governance. The federal rule requires at least 30 percent of school feeding resources to be used for direct purchases from family farmers, with priority for local and socially targeted producers. Municipalities implement procurement, school menus, and delivery, while school feeding councils provide local oversight. Sidaner *et al*. (2013) frame PNAE as an integrated food and nutrition security program. Silva *et al*. (2023) show that the rule requires mediation among municipal authorities, schools, farmers, cooperatives, nutritionists, and councils.

The policy lesson is that local procurement requires more than a local purchase target. It needs supplier organization, menu planning, payment reliability, product quality control, transport, and transparent contracting. Local governments can create demand for family farming, but national standards and financing help protect nutrition goals and fiscal continuity.

4.3. Food price monitoring and market management

Local authorities often manage wholesale and retail markets, market fees, sanitation, storage sites, and local transport bottlenecks. These functions can influence consumer prices and food safety. Local price monitoring can also feed early warning systems. A decentralized price-monitoring arrangement should define who collects prices, how often, which commodities are covered, how data are validated, and which response rules are triggered. Local data becomes valuable only when they are comparable across markets and connected to national or provincial response capacity.

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4.4. Nutrition, health, and social protection

Nutrition programs require local targeting and repeated contact with households. Growth monitoring, maternal counseling, school meals, water and sanitation, health outreach, and social protection all depend on frontline workers and local institutions. The risk is that local targeting can be captured or biased against socially marginal groups. Transparent criteria, appeal systems, and oversight beyond the village are therefore central. Ethiopia's Productive Safety Net Program shows both the promise and difficulty of local targeting in food-insecure areas, as discussed below.

Box 5.2 Ethiopia: PSNP and local targeting

Ethiopia's Productive Safety Net Program is among the most studied safety-net programs in Africa. Gilligan *et al*. (2009) assess PSNP as the largest social protection program in Sub-Saharan Africa outside South Africa at that time. Targeting and implementation involve woreda and kebele structures, food-security task forces, and community processes. Sharp *et al*. (2006) found that the 2006 targeting process became more community driven and transparent than the earlier cycle, with woreda and kebele food security task forces and community meetings.

The Ethiopian case shows that local targeting can identify chronic food insecurity, but it also requires clear criteria, transfer reliability, public works planning, and capacity support. Gilligan *et al*. (2009) found limited average effects where transfers fell below planned levels, while larger effects appeared for households receiving more complete transfers. This points to a broader decentralization lesson: local targeting cannot compensate for inadequate transfer size, payment delay, or weak program finance.

4.5. Land, water, fisheries, and natural resource governance

Food security depends on tenure and resource access. Local governments and customary institutions often influence land-use planning, water allocation, grazing access, fisheries rules, and dispute resolution. The FAO Voluntary Guidelines on the Responsible Governance of Tenure set principles for responsible governance of land, fisheries, and forests in the context of national food security (FAO, 2012).

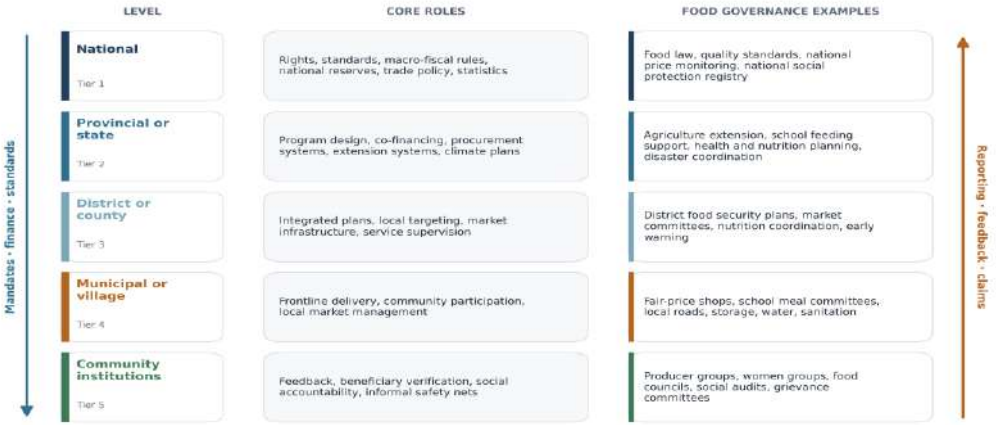
LEVEL
CORE ROLES
FOOD GOVERNANCE EXAMPLES
National
Tier 1
Rights, standards, macro-fiscal rules, national reserves, trade policy, statistics
Food law, quality standards, national price monitoring, national social protection registry
Provincial or state
Tier 2
Program design, co-financing, procurement systems, extension systems, climate plans
Agriculture extension, school feeding support, health and nutrition planning, disaster coordination
District or county
Tier 3
Integrated plans, local targeting, market infrastructure, service supervision
District food security plans, market committees, nutrition coordination, early warning
Municipal or village
Tier 4
Frontline delivery, community participation, local market management
Fair-price shops, school meal committees, local roads, storage, water, sanitation
Community institutions
Tier 5
Feedback, beneficiary verification, social accountability, informal safety nets
Producer groups, women groups, food councils, social audits, grievance committees
Mandates · finance · standards
Reporting · feedback · claims

Figure 5.2. Multilevel Food Governance Architecture

Note. Prepared by the authors. Arrows indicate that authority and accountability move in both directions: downward through mandates and finance, upward through reporting, feedback, and claims.

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Local institutions can make tenure governance more accessible, but they can also entrench exclusion if women, tenants, pastoralists, Indigenous communities, fishers, and migrants lack voice. National rights protections and accessible dispute resolution are therefore necessary complements to local authority.

5. Risks and failure mechanisms

The food security case for decentralization is strong but conditional. Many reforms fail not because local governance is a poor idea, but because transfer of responsibility is not matched by clear authority, finance, capacity, and accountability. The most common failure mechanisms are unfunded mandates, elite capture, uneven local capacity, fragmented policy, exclusion, and weak data.

5.1. Unfunded mandates

Unfunded mandates arise when local governments become responsible for agriculture, nutrition, social protection, or market infrastructure without predictable resources. This problem is common in developing economies where central governments retain revenue while assigning expenditure responsibilities downward. Local officials then ration services, delay payments, depend on donor projects, or shift blame upward. Formula-based transfers, minimum service grants, contingency finance, and clear reporting rules reduce this risk. Fiscal decentralization must therefore be assessed by spending discretion and revenue predictability, not merely by the number of functions assigned locally.

5.2. Elite capture and local patronage

Elite capture is a central concern in local food governance. Procurement contracts, beneficiary lists, land-use decisions, irrigation allocation, and public works sites can generate local rents. Bardhan and Mookherjee (2006) emphasize that decentralization can increase accountability or capture depending on local political structure and information conditions. Food programs are especially exposed because targeting decisions and procurement contracts often involve repeated local relationships. Safeguards include public disclosure, conflict-of-interest rules, open beneficiary lists, independent audit, rotating committee membership, civil society monitoring, and appeal mechanisms outside the village.

5.3. Uneven capacity across territories

Decentralization can widen territorial inequality when richer or better-administered localities use new authority more effectively than poorer areas. Wealthier districts may have stronger tax bases, better staff, more internet access, better roads, and more organized producer groups. Poorer districts may face higher need but lower capacity. Equalization transfers, capacity grants, shared technical services, and provincial or national support teams are necessary to prevent decentralization from becoming a mechanism for unequal service quality.

5.4. Fragmentation and policy incoherence

Food security requires coherence across markets, trade, agriculture, health, climate, and welfare. Fragmentation appears when local discretion creates incompatible data systems, procurement standards, beneficiary lists, and emergency procedures. Central governments can prevent fragmentation without recentralizing all decisions by setting minimum standards, data protocols, transfer rules, and shared performance metrics. The objective is guided flexibility: national equity and safety standards with enough local room to adapt delivery.

5.5. Exclusion and weak representation

Local participation does not automatically include those most affected by food insecurity. Women may be formally present but unable to speak freely. Landless workers, minority groups, informal traders, pastoralists, and migrants may be outside formal village institutions. Local food councils and committees should therefore use explicit inclusion rules, safe meeting formats, accessible language, childcare support where relevant, and

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feedback channels that do not depend entirely on attendance at public meetings. Participation is meaningful when it changes planning, monitoring, and resource allocation.

RISK
FAILURE MECHANISM
DESIGN RESPONSE
1 Unfunded mandate
Functions transferred without matching finance.
Formula-based transfers, minimum service grants, fiscal transparency.
2 Elite capture
Local elites influence targeting, procurement, and land decisions.
Open beneficiary lists, social audits, conflict-of-interest rules, civil society monitoring.
3 Uneven capacity
Poorer districts lack staff, data, logistics, and procurement capacity.
Capacity grants, shared services, national technical support, peer learning.
4 Fragmentation
Local discretion creates incompatible standards and weak data flows.
National standards, interoperable data systems, joint planning forums.
5 Exclusion
Women, landless workers, minority groups, migrants, and informal traders are underrepresented.
Inclusive quotas, women-led committees, language access, mobile grievance channels.
6 Short political horizons
Local leaders favor visible projects over maintenance or nutrition.
Performance contracts, public scorecards, multiyear funding, evaluation.
Risk
Failure mechanism
Design response

Figure 5.3. Local Governance Risk Pathways and Design Responses

Note. Prepared by the authors from the governance and participation literature. The figure should be read as a diagnostic checklist for program design.

6. Comparative evidence from selected developing economies

The empirical record on decentralization and food security is mixed because countries decentralize different functions under different political and fiscal conditions. A useful comparison should therefore separate the formal structure of government from fiscal scope and from program design. Table 5.4 uses selected countries that represent contrasting governance settings. The fiscal data come from SNG-WOFI country profiles, which provide comparable information on subnational government finance. The table does not claim that higher subnational expenditure automatically improves food security. It shows the fiscal space within which local food governance may operate.

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Table 5.4. Selected-Country Indicators for Decentralization and Food Governance

Country	Main devolution feature	Fiscal scope	Food governance relevance	Main sources
Pakistan	Federal polity with post-2010 provincial devolution under the 18th Amendment; local-government continuity varies by province.	SNG expenditure: 7.6% of GDP and 32.8% of general government expenditure in 2020.	Agriculture and rural development functions sit heavily with provinces, increasing the need for national-provincial coordination in food security, nutrition, and data systems.	SNG-WOFI Pakistan profile; Resnick & Rana, 2016; GoP, 2018.
India	Federal system with elected local bodies and strong state-level roles in food distribution, school meals, and nutrition implementation.	SNG expenditure: 16.1% of GDP and 62.5% of public expenditure in 2018.	National entitlements depend on state and local delivery networks, fair-price shops, beneficiary verification, and local grievance mechanisms.	SNG-WOFI India profile; GoI NFSA portal; Shrinivas *et al*., 2025.
Indonesia	Post-1998 decentralization placed major service functions with provinces, districts, municipalities, and villages.	Calculated SNG expenditure: 9.0% of GDP and 46.6% of public expenditure in 2020.	District and village institutions influence agricultural services, local infrastructure, food reserves, and ecological screening of food projects.	SNG-WOFI Indonesia profile.
Kenya	2010 Constitution created county governments with devolved functions including agriculture, health, and local infrastructure.	County expenditure: 3.8% of GDP and 15.5% of general government expenditure in FY 2019/20.	County authorities can link agriculture, health, nutrition, climate planning, and public participation, but counties rely heavily on transfers.	SNG-WOFI Kenya profile; FAO Kenya CPF 2022-2026.
Brazil	Federal system with municipalities serving as core implementers of school feeding and local procurement rules.	SNG expenditure: 22.4% of GDP and 44.4% of public spending in FY 2020.	Municipal implementation and school feeding councils anchor local procurement from family farming under PNAE.	SNG-WOFI Brazil profile; Sidaner *et al*., 2013; Silva *et al*., 2023.
Ethiopia	Federal system with regional states and woredas central to implementation of safety nets and services.	Subnational expenditure: 7.8% of GDP and 57.1% of general government expenditure in FY 2017/18.	Woreda and kebele structures are central to PSNP targeting, public works, and food-security transfers.	SNG-WOFI Ethiopia profile; Sharp *et al*., 2006; Gilligan *et al*., 2009.
Bangladesh	Centralized unitary system with urban local bodies and limited subnational fiscal scope.	Urban SNG expenditure: 5.1% of total budgetary expenditure and < 1% of GDP in FY 2019/20.	Local food governance is constrained by narrow fiscal space, though municipalities can influence markets, sanitation, and urban food access.	SNG-WOFI Bangladesh profile.

Note. Prepared by the authors using SNG-WOFI country profiles and cited country case literature. Figures are descriptive and use the latest profile year available. Bangladesh is limited to urban subnational government data in the SNG-WOFI profile.

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Figure 5.4. Fiscal Scope of Subnational Governments in Selected Countries

Note. Source: SNG-WOFI country profiles. Values are descriptive and do not imply a causal relationship with food security. Indonesia is calculated from the profile's provincial and regency/city/village components. Bangladesh is shown as a separate marker because the SNG-WOFI profile provides only a less-than-one-percent GDP value for urban subnational governments.

6.1. Pakistan: provincial devolution and the coordination problem

Pakistan is central to this chapter because it shows the promise and difficulty of devolution in a food-insecure developing economy. The 18th Amendment, passed in 2010, transferred major functions to provinces and altered the balance of federal and provincial authority. Resnick and Rana (2016) argue that the amendment has important implications for agriculture, rural development, and food security. The Government of Pakistan's National Food Security Policy also notes that after the amendment, provinces assumed major responsibility for agriculture and rural development, while the Ministry of National Food Security and Research was created at the federal level in 2011 (Government of Pakistan, 2018).

The reform created space for provinces to tailor agriculture, rural development, livestock, water, and nutrition interventions. It also created coordination demands. Food security needs national price monitoring, trade policy, reserves, seed and input quality standards, plant and animal health rules, and national data systems. Provincial autonomy is useful when provinces can design locally appropriate programs, but harmful when common standards, data comparability, or emergency coordination weaken. Pakistan's challenge is not to reverse devolution, but to build institutions for federal-provincial and provincial-local coordination.

Box 5.3 Pakistan: after the 18th Amendment

Pakistan's devolution experience shows why decentralization should be paired with coordination. The 18th Amendment transferred many social and economic functions to provinces. Agriculture and rural development became heavily provincial responsibilities, while the federal government retained roles in national coordination, external commitments, trade, standards, and food security policy.

Three lessons follow. First, provincial authorities can make food policy more responsive to crop zones, water scarcity, livestock systems, and rural poverty patterns. Second, provincial food policy still requires national data and standards. Third, elected local governments are needed if provincial devolution is to reach district and village priorities. Without durable local institutions, authorities may stop at the provincial capital rather than reaching communities.

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6.2. India: national entitlements and state-local delivery

India illustrates a different pattern: national food entitlements and large-scale public distribution rely on state and local delivery systems. The official National Food Security Act portal describes the Public Distribution System as a mechanism that evolved from scarcity management into an important part of the government's food economy policy (Government of India, n.d.). The National Food Security Act of 2013 created one of the largest food transfer expansions in history, affecting more than 500 million people, according to Shrinivas *et al*. (2025). This case is not simple decentralization because the entitlements are national, but implementation depends on state procurement, distribution logistics, fair-price shops, local beneficiary systems, and grievance mechanisms.

India's experience shows that decentralization may operate through a layered system rather than full local autonomy. The central state finances and regulates large food transfer programs, state governments shape implementation quality, and local institutions handle ration shops, records, monitoring, and complaints. Digital authentication and portability reforms can improve portability, but they also require safeguards for households facing biometric failure, connectivity gaps, or documentation barriers. Local food governance remains important because exclusion often occurs at the final transaction point.

6.3. Kenya: counties and integrated local planning

Kenya's 2010 Constitution created county governments with authority over functions related to agriculture, health, local infrastructure, and planning. SNG-WOFI reports that county expenditure was 3.8 percent of GDP and 15.5 percent of general government expenditure in FY 2019/20, with grants and subsidies forming a very large share of county revenue. The FAO Country Programming Framework for Kenya 2022-2026 states that agricultural functions in Kenya are devolved to county governments while national ministries and other actors continue to operate in the sector (FAO, 2023).

Kenya shows the local integration advantage of devolution. Counties can connect agriculture, health, nutrition, drought preparedness, and local infrastructure within county plans. The fiscal caution is that counties rely heavily on transfers, and delays or political disputes over intergovernmental finance can weaken implementation. County public participation requirements create a platform for food governance, but participation has to be tied to budgets and service monitoring to be effective.

Box 5.4 Kenya: counties as food-system coordinators

Kenya's county governments are well placed to connect food production, nutrition, health, and climate adaptation because many relevant functions sit near the county level. County planning can identify local food-system constraints such as poor feeder roads, weak livestock services, water stress, market sanitation, and nutrition gaps.

The main design issue is fiscal and administrative capacity. Counties need predictable transfers, own-source revenue where feasible, staff capability, procurement integrity, and intercounty coordination for issues such as pastoral mobility, watersheds, and regional markets. Public participation can strengthen local legitimacy, but only when citizen priorities are connected to budget decisions and monitoring reports.

6.4. Brazil: local procurement and social oversight

Brazil's PNAE case demonstrates how national law and local implementation can create a local food procurement architecture. Sidaner *et al*. (2013) describe PNAE as part of Brazil's wider experience in building an integrated food and nutrition security system. Silva *et al*. (2023) emphasizes the importance of municipal implementation and the 30 percent family farming procurement rule. The institutional strength of the case lies in the combination of federal finance, national nutrition and procurement rules, municipal execution, and local oversight through school feeding councils. The Brazilian lesson is that local procurement should not be treated as a purely market transaction. Smallholder participation depends on organization, transport, product standardization, payment reliability, and menu planning. Local governments

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can support these conditions, but they need national fiscal continuity and technical guidance. Local procurement can be a food-security tool when it serves both consumers and producers without sacrificing nutrition standards or procurement transparency.

6.5. Indonesia: local authority and national food-security projects

Indonesia's decentralization reforms moved substantial responsibilities to districts, municipalities, villages, and provinces. SNG-WOFI reports that regency, city, and village expenditures amounted to 6.9 percent of GDP and 35.5 percent of public expenditure in 2020, while the provincial level accounted for 2.1 percent of GDP and 11.1 percent of public expenditure. Aggregating those profile components gives 9.0 percent of GDP and 46.6 percent of public expenditure for the selected figure in this chapter.

Indonesia is useful because it shows that formal decentralization can coexist with national food-security projects that require local ecological screening and social consent. Large food-estate or land-development projects may be promoted as national food-security interventions, but local governments and communities bear many ecological, tenure, and livelihood effects. The governance lesson is that decentralized food systems need national ambition and local checks. Land suitability, water availability, forest risk, Indigenous and customary claims, labor conditions, and local market effects should be assessed before projects are approved.

6.6. Ethiopia: local implementation under a federal system

Ethiopia combines federal and local administrative structures with large food-security and safety-net programs. SNG-WOFI reports subnational expenditure at 7.8 percent of GDP in FY 2017/18, with substantial public employment and service delivery responsibilities at regional and woreda levels. PSNP demonstrates the strengths and limits of local targeting. Community and kebele structures can identify vulnerable households, but program effects also depend on transfer adequacy, payment reliability, public works quality, and national finance. Ethiopia's experience warns against romanticizing local knowledge. Local targeting is valuable, but it does not solve underfunding or weak implementation capacity.

Table 5.5. Participation and Accountability Instruments in Local Food Governance

Instrument	How it works	Food-governance use	Design caution
Participatory budgeting	Citizens propose or prioritize budget items for local plans.	Useful for small infrastructure, market improvements, water points, and nutrition facilities.	May favor organized groups unless outreach is deliberate.
Local food councils	Multi-actor forums link producers, consumers, officials, schools, health workers, and civil society.	Can integrate food access, diet quality, procurement, and market governance.	Requires legal mandate, minutes, follow-up, and budget links.
School feeding committees	Parents, teachers, nutrition staff, and local leaders monitor meals and suppliers.	Improves scrutiny of menus, delivery, quality, and inclusion.	Needs training and protection from supplier capture.
Social audits	Public review of program lists, spending, contracts, and delivery.	Can reduce leakage in safety nets, procurement, and public works.	Requires access to records and independent facilitation.
Grievance redress	Citizens submit complaints about exclusion, quality, delays, corruption, or abuse.	Creates a route for correction beyond local gatekeepers.	Must include appeals, deadlines, and safe channels.
Digital feedback systems	Mobile, web, SMS, or call-center channels report prices, stockouts, or complaints.	Can speed monitoring and widen access.	Must not exclude households without connectivity or literacy.

Note. Prepared by the authors using participation and social accountability literature, especially Mansuri and Rao (2013) and World Bank (2003).

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Table 5.6. Country Case Comparison: Decentralization and Food Governance

Country	Devolution pattern	Food-governance function	Strength	Main lesson
Pakistan	Provincial devolution after the 18th Amendment.	Agriculture and rural development became heavily provincial.	Provincial adaptation potential; federal coordination remains central.	Build federal-provincial data and planning systems; strengthen elected local governments.
India	National entitlements with strong state and local delivery.	PDS and NFSA rely on distribution networks, fair-price shops, and local records.	Large scale and rights-based entitlements can reduce deprivation when delivery works.	Protect portability and digital reform with safeguards for exclusion.
Brazil	Federal school feeding rules with municipal execution.	PNAE links school feeding with family farming procurement.	Local procurement can support diets and smallholders.	Supplier support and transparent contracting are needed.
Kenya	County governments created under the 2010 Constitution.	Agriculture, health, and local infrastructure functions sit near county level.	Counties can integrate food systems and nutrition planning.	Predictable transfers and intercounty coordination are required.
Indonesia	Post-1998 decentralization to provinces, districts, cities, and villages.	Local authorities influence services, villages, infrastructure, and environmental screening.	Local knowledge can check poor project fit.	National projects need local consent, safeguards, and ecological review.
Ethiopia	Federal regions and woredas implement major safety-net functions.	PSNP relies on local targeting and public works planning.	Local targeting can identify chronic vulnerability.	Transfer adequacy and implementation capacity remain decisive.

Note. Prepared by the authors from the case literature cited in this chapter. The table is comparative synthesis, not a ranking.

7. Design principles for effectively decentralized food governance

The comparative discussion suggests that local food governance should be built around seven design principles.

7.1. Clarify functions before transferring responsibility

Governments should specify which level is responsible for policy design, finance, implementation, monitoring, and appeal. Ambiguity creates delay and blame shifting. A useful rule is to keep rights, standards, macro-fiscal stability, trade policy, food safety norms, and national data architecture at higher levels, while allowing subnational governments to adapt delivery, integrate local sectors, and manage local infrastructure. Functions should be reviewed periodically because capacity and technology change over time.

7.2. Match authority with finance

Local governments need predictable, timely, and adequate finance. Formula-based transfers should account for population, poverty, food insecurity, geography, climate exposure, and service costs. Performance grants can encourage reporting and quality improvements but should not penalize poor districts that begin with lower capacity. Contingency finance is especially important for drought, flood, conflict, and price shocks. Own-source revenue can support local accountability, but poor localities should not be asked to finance basic rights mainly from weak tax bases.

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7.3. Build administrative and data capacity

Decentralization requires staff, procurement systems, financial management, monitoring, and data infrastructure. Digital systems can help track prices, beneficiaries, transfers, and complaints, but they should be interoperable and accessible. Local officials need training in nutrition-sensitive planning, climate risk, procurement, gender inclusion, and conflict-sensitive targeting. Capacity-building should be treated as a standing investment rather than a one-off workshop.

7.4. Combine participation with enforceable accountability

Participation improves food governance only when it can change decisions. Local forums should have public agendas, records, feedback obligations, and access to budgets and program lists. Social audits and grievance systems should have deadlines and appeals. Committees should include women, smallholders, tenants, landless workers, youth, traders, and marginalized communities. Accountability also requires independent oversight from audit bodies, courts, media, civil society, and higher-level agencies.

7.5. Keep national standards with local flexibility

Food rights and nutrition standards should not depend on where a household lives. National standards should define minimum entitlements, food safety, procurement integrity, eligibility rules, and data protocols. Local governments should have flexibility over delivery arrangements, menus, infrastructure priorities, outreach, language access, and partnerships. This balance prevents fragmentation while preserving responsiveness.

7.6. Use decentralization to support nutrition-sensitive food systems

Local food governance should not focus only on staple availability. Diet diversity, child and maternal nutrition, safe water, health services, and food environments require local coordination. School meals, local procurement, market sanitation, extension for nutrient-dense crops, and women-centered planning can connect agriculture with diet quality. The affordability of healthy diets and food-price monitoring should be integrated into local dashboards where data permit.

7.7. Evaluate reforms by service quality and inclusion

A country can decentralize formally without improving food security. Evaluation should ask whether households receive services more reliably, whether food access improves for vulnerable groups, whether local procurement is transparent, whether complaints are resolved, whether nutrition indicators improve, and whether local systems respond faster to shocks. These criteria are more meaningful than the legal count of devolved functions.

8. Data, indicators, and measurement agenda

Better measurement is needed because decentralization is often measured through constitutional form rather than food governance practice. A practical indicator set should include both decentralization indicators and food-system indicators. On the governance side, SNG-WOFI provides subnational expenditure, revenue, investment, debt, and functional expenditure data. The Worldwide Governance Indicators provide annual composite indicators such as government effectiveness, voice and accountability, rule of law, and control of corruption (World Bank, 2025). V-Dem provides detailed democracy measures, including variables related to local government institutions (V-Dem Institute, 2025). On the food side, FAOSTAT and FAO SDG indicators provide food and agriculture data, while SDG indicator 2.1.2 measures moderate or severe food insecurity based on the Food Insecurity Experience Scale (FAO, 2026).

For future empirical work, three measurement strategies are recommended. First, build subnational panels where local government finance can be matched with district-level food insecurity, nutrition, price, and climate indicators. Second, separate fiscal scope from local accountability and administrative capacity. Third, use mixed methods: quantitative indicators can identify patterns, but case research is needed to understand whether local authority is real, whether participation affects budgets, and whether marginalized groups can use grievance systems.

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The figure and data used in this chapter are intentionally descriptive. Fiscal scope is a condition for local food governance, not proof of food-security performance. A country with high subnational expenditure may still perform poorly if spending is captured or poorly coordinated. A country with lower subnational expenditure may deliver well if national programs are strong and local implementation is well supervised. The key empirical task is to identify which combinations of authority, finance, capacity, participation, and accountability produce better services and more inclusive access.

9. Policy recommendations

For national governments, the priority is to design decentralization as a system. Food security functions should be assigned through law or regulation, supported by finance, linked to data, and reviewed through performance monitoring. Central ministries should not micromanage local delivery, but they should set standards, maintain national data infrastructure, fund equalization, and coordinate responses to shocks. National food-security strategies should include an intergovernmental chapter that specifies roles for provinces, states, districts, municipalities, villages, and community institutions.

For provincial and state governments, the priority is to translate national commitments into territorially differentiated programs. Provinces and states should support districts through technical assistance, pooled procurement where useful, extension systems, nutrition-sensitive planning, and performance reporting. They should avoid retaining all authority at the provincial capital. Devolution within provinces is necessary if district and community knowledge is to shape policy.

For district, county, municipal, and village governments, the priority is to integrate food-security planning across sectors. Local plans should connect agriculture, roads, markets, water, health, nutrition, education, and social protection. Planning should use price data, vulnerability maps, beneficiary feedback, and public hearings. Local governments should publish budgets, procurement awards, beneficiary criteria, grievance statistics, and service reports in accessible formats.

For development partners, the priority is to avoid project structures that bypass local institutions while claiming to support local governance. Donor programs should strengthen public systems, finance capacity-building, support interoperable data, and fund evaluation. Pilot projects should include a credible path to scale within government budgets and rules. Donors should also support peer learning among local governments because practical implementation knowledge often travels well across similar territories.

For civil society and producer organizations, the priority is to make participation consequential. Farmer groups, women's organizations, consumer associations, and social accountability actors can monitor procurement, beneficiary selection, school meals, market conditions, and grievance systems. Their role is strongest when they have access to information, protection from retaliation, and formal channels for follow-up.

10. Closing argument

Decentralization can make food security policy more responsive, inclusive, and adaptive, but only when it is built as a coherent governance system. Local governments and community institutions bring information, proximity, and participatory possibilities that central ministries cannot replicate. Yet those advantages are fragile. Without finance, staff, data, accountability, and coordination, decentralization may shift responsibility downward while keeping real capacity elsewhere. It may also empower local elites rather than food-insecure households.

The practical lesson is to reject both extremes. Centralized food policy often misses local variation and weakens participation. Unstructured decentralization can create fragmentation and unequal service quality. The stronger path is multilevel food governance: national standards and rights, provincial and state coordination, district and county planning, municipal and village delivery, and community accountability. This arrangement treats local participation not as decoration but as part of the institutional architecture of food security.

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For developing economies facing climate risk, fiscal constraint, rapid urbanization, food price instability, and persistent malnutrition, local food governance will become more important. The challenge is not simply to devolve. The challenge is to design decentralized systems that can learn, coordinate, correct errors, and protect the people most exposed to food insecurity.

References

Ahmad, J., Devarajan, S., Khemani, S., & Shah, S. (2005). *Decentralization and service delivery* (World Bank Policy Research Working Paper No. 3603). World Bank. https://documents1.worldbank.org/curated/en/606871468139500265/pdf/wps3603.pdf

Bardhan, P., & Mookherjee, D. (2006). Decentralisation and accountability in infrastructure delivery in developing countries. *The Economic Journal*, *116*(508), 101–127. https://doi.org/10.1111/j.1468-0297.2006.01049.x

Faguet, J.-P. (2014). Decentralization and governance. *World Development*, *53*, 2–13. https://doi.org/10.1016/j.worlddev.2013.01.002

Food and Agriculture Organization of the United Nations. (2012). *Voluntary guidelines on the responsible governance of tenure of land, fisheries and forests in the context of national food security*. https://openknowledge.fao.org/items/609a716c-464c-4454-9222-78f5e7cd23f7

Food and Agriculture Organization of the United Nations. (2023). *Country programming framework for Kenya 2022–2026*. https://www.fao.org/kenya/our-office-kenya/country-programming-framework/en

Food and Agriculture Organization of the United Nations. (2026). *Indicator 2.1.2: Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale*. FAO SDG Data Portal. https://www.fao.org/sustainable-development-goals-data-portal/data/indicators/212-prevalence-of-moderate-or-severe-food-insecurity-in-the-population-based-on-the-food-insecurity-experience-scale/en

Gilligan, D. O., Hoddinott, J., & Taffesse, A. S. (2009). The impact of Ethiopia's Productive Safety Net Programme and its linkages. *Journal of Development Studies*, *45*(10), 1684–1706. https://doi.org/10.1080/00220380902935907

Government of India, Department of Food and Public Distribution. (n.d.). *Public Distribution System (PDS)*. National Food Security Portal.

Government of Pakistan, Ministry of National Food Security and Research. (2018). *National food security policy*. https://api.gov.pk/SiteImage/Downloads/National%20Food%20Security%20Policy%202018.pdf

High Level Panel of Experts on Food Security and Nutrition. (2020). *Food security and nutrition: Building a global narrative towards 2030*. Committee on World Food Security. https://openknowledge.fao.org/server/api/core/bitstreams/8357b6eb-8010-4254-814a-1493faaf4a93/content

Mansuri, G., & Rao, V. (2013). *Localizing development: Does participation work?* World Bank. https://doi.org/10.1596/978-0-8213-8256-1

Oates, W. E. (1972). *Fiscal federalism*. Harcourt Brace Jovanovich.

Oates, W. E. (1999). An essay on fiscal federalism. *Journal of Economic Literature*, *37*(3), 1120–1149. https://doi.org/10.1257/jel.37.3.1120

Resnick, D., & Rana, A. W. (2016). Devolution in Pakistan: Implications for agriculture and rural development. In D. J. Spielman, S. J. Malik, P. A. Dorosh, & N. Ahmad (Eds.), *Agriculture and the rural economy in Pakistan: Issues, outlooks, and policy priorities* (pp. 351–378). University of Pennsylvania Press. https://cgspace.cgiar.org/server/api/core/bitstreams/08b5f99b-6398-4411-87e7-3e426ff53f1c/content

Sharp, K., Brown, T., & Teshome, A. (2006). *Targeting Ethiopia's Productive Safety Net Programme (PSNP)*. Overseas Development Institute. https://odi.org/en/publications/targeting-ethiopias-productive-safety-net-programme-psnp/

Shrinivas, A., Baylis, K., & Crost, B. (2025). Food transfers and child nutrition: Evidence from India's Public Distribution System. *American Economic Journal: Applied Economics*, *17*(3), 161–207. https://doi.org/10.1257/app.20220505

Sidaner, E., Balaban, D., & Burlandy, L. (2013). The Brazilian school feeding programme: An example of an integrated programme in support of food and nutrition security. *Public Health Nutrition*, *16*(6), 989–994. https://doi.org/10.1017/S1368980012005101

Silva, E. A. da, Pedrozo, E. A., & Silva, T. N. da. (2023). The PNAE (National School Feeding Program) activity system and its mediations. *Frontiers in Environmental Science*, *10*, Article 981932. https://doi.org/10.3389/fenvs.2022.981932

Tiebout, C. M. (1956). A pure theory of local expenditures. *Journal of Political Economy*, *64*(5), 416–424. https://doi.org/10.1086/257839

V-Dem Institute. (2025). *The V-Dem dataset*. University of Gothenburg. https://www.v-dem.net/data/the-v-dem-dataset/

World Bank. (2003). *World development report 2004: Making services work for poor people*. World Bank and Oxford University Press.

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https://documents1.worldbank.org/curated/en/832891468338681960/pdf/268950WDR00PUB0ces0work0poor0people.pdf

World Bank. (2025). *Worldwide governance indicators*. https://www.worldbank.org/en/publication/worldwide-governance-indicators

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CHAPTER 06

Political Economy of Subsidies, Procurement, and Price Controls

Ahmad Abdul Wahab[1,*], Muhammad Asad ur Rehman Naseer[2], Shoaib Akhtar[2] & Muhammad Talha Arshad[3]
[1] Institute of Agronomy, FAS&T, Bahauddin Zakariya University, Multan, Pakistan
[2] Department of Agricultural Business & Marketing, FAS&T, Bahauddin Zakariya University, Multan, Pakistan
[3] Department of Plant Breeding and Genetics, Muhammad Nawaz Shareef-University of Agriculture, Multan, Pakistan
Corresponding author's email: ahmadabdulwahab95@gmail.com

Abstract

The tools of the developing world governments provided agricultural subsidies, public procurement systems, and price controls that still have the potential to spark some of the most politically charged and economically devastating reactions from the people they serve. This chapter provides an extensive overview of the political economy processes and their impact on the design and implementation of these interventions in a very varied set of developing economies, exploring the role of distributional coalitions, electoral politics, bureaucratic interests and institutional path-dependencies. Based on evidence from South Asia, Sub-Saharan Africa, the Middle East and Latin America, the chapter argues that the persistence of high cost, low efficiency food policies is not solely a consequence of technical ignorance but a reflection of sound political motives in some contexts, especially in states that lack social protection, have high rural poverty, and are characterized by weak state capacity. It builds a four-pillar analytical framework, based on principal-agent theory, collective action problems, institutional path dependence and distributional coalition theory, to understand the lifecycle of food policy instruments. It delivers detailed insights into the architecture of subsidy programs, governance problems in the procurement system (such as high leakage rates and fiscal waste reported in India, Egypt, Pakistan, and Indonesia), and welfare implications of retail price control structures. Special focus is given to the political environment that facilitates or hinders reform, such as civil society, technocratic capacity, and international financial institutions. The chapter ends with a sequenced roadmap for reform with a focus on fiscal sustainability, poverty targeting and market development, yet recognizes that reformers must face political feasibility challenges.

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1. Introduction and Political Economy Framework

1.1. Setting the Stage: Why Food Policy is Always Political

Food security is an economic, moral and political issue. The right to adequate food, as defined in the Universal Declaration of Human Rights, Article 25, (United Nations, 1948) and developed in the International Covenant on Economic, Social and Cultural Rights, requires normative responsibilities of States (United Nations, 1966), But these means of realizing that obligation are always influenced by technical efficacy and targeting considerations as well as by political considerations of electoral survival, coalition survival, and distributive bargaining. Political economy is thus not a separate issue from food policy, but an integral part of policy determination.

The total annual value of direct budgetary support to agriculture in developing countries was higher than USD 700 billion per year between 2000 and 2022, and was also complemented by USD 300 billion or more in implicit subsidies, through below-market input prices and favorable credit (OECD, 2023). Most of this spending is poorly directed, unfinanceable and vulnerable to elite capture; but reforms have not occurred. It's important to know why, and to dig deeper into the political economy of who benefits, who decides, and who pays the costs of food policy.

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This chapter is organized as follows. In Section 1, the analytical framework is developed. The discussion of the agricultural subsidies in Section 2 is in detail. The public procurement systems are analyzed in Section 3. Price controls and market regulation are discussed in Section 4. Section 5 presents pathways for reform and Section 6 provides conclusions and recommendations.

1.2. Analytical Framework: Four Pillars

Principal-Agent Theory

The principal-agent theory can serve as a basic framework to explain the governance failures in food policy. The principal-agent theory offers a basic framework to understand governance failures in food policy. Government (principal) delegation to bureaucracies, state enterprises or local government officials (agent) allows for rent-seeking, corruption and goal displacement due to information asymmetries. He has, for instance, documented the diversion of rice from the subsidized Public Distribution System (PDS) by middlemen in India, where up to 47% of the subsidized rice is diverted before reaching the recipient households, because of the difficulty in monitoring the actions of the agents in the millions of fair price shops. The way in which accountability mechanisms are designed (whether as digitization of supply chains, community monitoring or beneficiary verification) directly influences the extent to which agent opportunism can be limited (Dreze and Khera, 2015).

Collective Action Problems

The theory of collective action Olson (1965), formulated and then adapted to the case of agricultural policy (Bates, 1981, 2008) and others, accounts for why small groups who are well-organized can secure policy benefits for themselves at the expense of large and diffuse populations. Large farmer unions, grain traders and the food processing conglomerates are well coordinated, politically active and well able to carry on the lobbying effort over the long term. The poor food consumers, by contrast, are far more numerous, and have classic "free-rider" issues in trying to organize to defend their interests. That means that, while subsidies are supposed to be targeted at the poor, they are often directed to relatively prosperous farmers (due to above-market procurement prices), to wealthy intermediaries (due to licensing rents), and onto the general taxpayer.

Institutional Path Dependence

Path dependency theory offers insights into the remarkably persistent nature of food policy instruments despite changes in their economic justification (North, 1990; Pierson, 2000; de Krom and Muilwijk, 2019). There are several ways in which institutions produce ‘lock-in' effects: they develop constituencies that resist change; they mold the interests and capacities of the bureaucracy in a way that makes other options seem precarious; and they become institutionalized in legal and administrative processes that are difficult to unwind. The Indian case of fertilizer subsidies, which was introduced after the Green Revolution, and Egypt's case of bread subsidies, which was introduced in the context of Nasser's Arab socialist project, are illustrative of such phenomenon in that they have been institutionalized for decades and have powerful path dependencies that make change difficult even for well-intentioned reformers (Birner & Resnick, 2010).

Distributional Coalition Theory

Distributional coalition theory draws on Olson's later work (1982) and its application to food policy by Pinstrup-Andersen (1988) and Kherallah *et al*. (2002). These individuals look at how organized interests capture the rents created by policy distortions and spend the resources over time to maintain the distortions. In many developing nations, the political opposition to agricultural price controls and procuring systems brings together a group of large farmers (as their incomes benefit from minimum support prices), urban workers (who benefit from low retail prices), food processors (because their raw materials are cheap) and bureaucratic agencies whose budgets and employment rely on program management. This coalition is a heterogeneous group, but they have a stake in the maintenance of the policy regime which makes reform politically costly even if it is economically desirable.

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Key Analytical Insight

It is not only because of the continuation of economically inefficient food policies in developing economies. It was either because of technical ignorance or institutional weakness. Such policies may have logical political purposes such as delivering,

It makes a difference to key constituencies that are visible, immediate and tangible in terms of benefits; and those costs, fiscal drain, are also felt. The answers to questions like what is market distortion? What counts as investment crowding-out? or who wins and who loses from investment crowding-out? are vague, remote, and hard to see politically. Superior policy design is not enough, however, for effective reform; a political strategy for managing must be in place as well. The distributional coalition supporting the status quo (Birner & Resnick, 2010; Pinstrup-Andersen, 1988).

1.3. The Impact of Development Aid on the Food Security Position

A considerable amount of empirical research has been carried out to establish the impact of electoral cycles on food policy. There is a large amount of empirical literature that establishes the impact of electoral cycles on food policy. They identified positive relationships between rising allocations of fertilizer subsidies and the 12 months before a national election in the twelve nations in Sub-Saharan Africa. In the twelve countries in Sub-Saharan Africa, they discovered that there was a 2.3 times greater chance of an increase in fertilizer subsidy in the 12 months leading up to a national election than in non-election years. In South Asian democracies, wheat and rice procurement prices have been revised up in election years and down after the poll and, in general, the price of wheat and rice was revised upwards during election periods (Varshney, 1998). The patterns mirror the importance of food prices and agricultural incomes in elections in mostly rural developing nations and highlight how the political business cycle influences food policy design.

2. Political Economy of Agricultural Subsidies

2.1. Typology and Scale of Agricultural Subsidies

Agricultural subsidies in developing economies are a diverse set of measures, including support for inputs such as fertilizers, seeds, pesticides, and energy (for irrigation and farm machinery); credit subsidies (rates of interest on agricultural loans that are lower than market rates, offered by state banks); minimum support prices (MSPs) (which are the minimum prices paid to farmers for their output, in the event that the market price is lower); and support for output. Summarizes the fiscal incidence of these measures in selected developing economies Table 6.1

Table 6.1: Agricultural Subsidy Expenditure in Developing Counties (2021–2022)

Subsidy material	Year	Agriculture Subsidy (GDP %)	Country
Wheat support price	2022	1.4%	Pakistan
Energy and Rice	2022	1.2%	Indonesia
Irrigation and Fertilizer	2022	1.1%	Bangladesh
PROAGRO/ PROCAMPO	2022	0.9%	Mexico
Fertilizer and food public distribution system (PDS) 35 kg of rice and wheat per month	2022	2.8%	India
Fuel and bread	2021	1.9%	Egypt
Fertilizer	2021	0.6%	Nigeria
Input Vouchers	2021	0.4%	Ethiopia

Source: World Bank (2023); IMF Fiscal Monitor (2023); national ministry of finance documents.

Table 6.1 India's subsidy bill alone cost only 65 billion USD only in the year of 2021-22 that contains food, fertilizers, irrigation, and power for agriculture which was approximately equivalent to 2.8% of India GDP (Ministry of Finance, Government of India, 2022). TAMWEEN was an Egypt's food subsidy system (FSS) that was 1.9% of GDP approximately in 2021 that provided the cooking oil, bread, and other essential commodities through rationing card system (IMF, 2022).

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2.2. The Political Economy of Fertilizer Subsidies

The Fertilizer Subsidy Complex in India

The Indian Government's fertilizer subsidy program is one of the most widely researched subsidy policies for agricultural inputs in the developing world. The Government of India has been running a policy that the retail price of fertilizers is capped at a controlled price and the difference between the controlled price and the cost of production is paid directly to the manufacturer by the government, and the subsidy bill goes through the Fertilizer Industry Coordination Committee (FICC) and finally to the Department of Fertilizers. This mechanism resulted in an EXHUSTER cost of INR 1.62 trillion (USD 20 billion) in 2021-22, with urea accounting for more than 60% of the cost (Comptroller and Auditor General of India [CAG], 2022).

This program is a complex political economy. On the demand side, the beneficiary coalition is made up of some 150 million cultivator households, whose salience in Indian democracy is tremendous and most of the states' assemblies, and a significant plurality of the Lok Sabha, are agriculturally dependent. On the supply side, the fertilizer industry, especially domestic urea producers, has the advantage of assured volume demand and effectively socialized costs of production, pushing up the cost of competing with free trade which creates an industrial lobby with strong reasons to oppose the reform of the fertilizer industry. In the past, it has been enough to defeat even technically sound proposals for reform (Gulati & Banerjee, 2015).

Africa's Fertilizer Subsidy Landscape

The situation in Sub Saharan Africa is very different. However, the average application of fertilizers in the region is still low at 17 kg/ha, which is lower than the average global application of more than 130 kg/ha, due to both the cost and market access issues (FAO, 2022). In response, several African governments have adopted input voucher programs and targeted fertilizer subsidies. Moreover, the Farm Input Subsidy Program (FISP) in Malawi, which was established in 2005 with the aim of supplying subsidized fertilizer vouchers to farmers, is often mentioned as a best-practice example – almost tripling maize production in three years (Dorward & Chirwa, 2011). Later assessments have shown, however, that targeting some beneficiaries has been significantly skewed politically, and that vouchers have been disproportionately distributed to households that are connected to networks of ruling party members (Dorward & Chirwa, 2011).

The Nigeria fertilizer subsidy scheme is an example of large-scale elite capture. These 'briefcase' agro-dealers, who were politically connected, used to confiscate an estimated 90% of the subsidized fertilizer before it reached the smallholder farmers before the Growth Enhancement Scheme (GES) reforms of 2012–2015 (Jayne & Rashid, 2013). Partially this was corrected by the introduction of direct electronic distribution of the GES, which was however still impeded by weak registry infrastructure and political pressures on the distribution logistics.

2.3. Why Subsidies Persist: A Political Economy Diagnosis

Several reinforcement mechanisms are brought to light in the literature that maintain inefficient subsidies. First, subsidies are self-generating because as their price is raised, their benefit goes to relatively few households, whereas the fiscal savings accrue to taxpayers, spreading across many. Second, subsidies are self-generating because as their price is raised, the benefit will go to relatively few households while the fiscal savings will go to taxpayers and spread across many. The asymmetry is a characteristic property of policy traps, as has been shown (Bates, 1981; de Gorter & Swinnen, 2002).

Second, the implementation of subsidy programs is carried out by bureaucracies that have significant self-preservation interests. Various agencies with institutional interests in the continuation and expansion of the program include those involved in fertilizer distribution, licensing of the fair price shops and in procurement operations. The Department of Food and Public Distribution has 40,000-plus civil servants in India at the center and millions more for the state food corporations (Dev, 2024). These bureaucracies are a formidable internal voice of the status quo.

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Thirdly, the information context of subsidy programs is often created not through independent evaluation, but by both the government and its target groups. Beneficiary-level impact data is often not collected, when it is, it is selectively published, and the counterfactual (what the poverty situation would have been without the other fiscal interventions) is by construction unobserved, making it difficult to rally a political coalition to a change on efficiency grounds.

2.4. Distributional Incidence: Who Really Benefits?

An interesting fact that has become common in empirical literature is that the distributional incidence of agricultural subsidies in developing countries is significantly regressive despite their apparent poverty alleviation and food security goals. Employing nationally representative household survey data, Jacoby (2016) showed that in India, the value of the fertilizer subsidy received per household was 3.6 times as high for the wealthiest quintile of the rural households as for the poorest, capturing the link between farm size, access to fertilizer, and the value of the subsidy received. This is like the results found in Pakistan (Dorosh & Salam, 2008), Egypt (Sdralevich *et al*., 2014), and Nigeria (Jayne & Rashid, 2013).

The inconsistent political implication is that the population of these programs tends to be drawn from people who have above average political mobilization capacity, since those who receive low benefit from input subsidies tend to be the people with less capacity to mobilize. One explanation for this is that input subsidy programs in the middle-income developing countries are more resistant to reform, where agricultural production has increased and a prosperous farmer class has developed.

3. Public Procurement Systems and Food Security Governance

3.1. Architecture and Functions of State Procurement

Public procurement of agricultural commodities has multiple conflicting goals: price stabilization (floor prices for producers), food security reserve accumulation (for crisis response and buffer stocks) and welfare delivery (as a source of agricultural supplies for subsidized distribution programs). The institutional structures in which these goals are achieved vary greatly in different developing economies: from state-only monopoly in procurement (as in India's Food Corporation of India), to multiple competing agencies in decentralized open market operations. Table 6.2 represents procurement system data scale, storage capacity metrics, and leakage rates (documented) across five developing economies.

Table 6.2: Public Procurement Systems: Comparative Performance Metrics

Department	Annual storage (MT)	Country	Price premium	*Leakage rate
Directorate General of Food (DGF)	1.5-2 million	Bangladesh	+8-14%	18-24%
Ethiopian Grain Trade Enterprise (EGTE)	0.2-1.2 million	Ethiopia	+5-10%	12-20%
Food Corporation of India (FCI)	60-80 million	India	+18-25%	36-47%
General Authority for Supply Commodities	4-6 million	Egypt	+10-15%	20-28%
Pakistan Agriculture Storage and Services Corporation (PASSCO)	3-5 million	Pakistan	+12-18%	25-35%

Source: Comptroller and Auditor General of India (2022); IMF (2022); World Bank (2023); respective national audit authorities."), *Leakage: difference between officially procured and physically received volume by departments, which represents the system failure of governance measures.

3.2. Hurdles in the implementation of large-scale procurement.

3.2.1. Food Corporation of India: Scale, Inefficiency and Attempts for reform.

Food Corporation of India (FCI) is one of the largest State Food procurement and distribution corporation of the world. The FCI procures 60-80 million metric tonnes of wheat and rice from the farmers at Minimum Support Prices (MSPs) every year, stores the grain in more than 1,500 storage depots with a combined capacity of over 100 million metric tonnes, and distributes the grain to more than 813 million beneficiaries through about 535,000 fair price shops as per the provisions of the National Food Security Act, 2013 (Ministry of Consumer Affairs, Food & Public Distribution, Government of India, 2022).

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This system has high running expenses. The Economic Cost of wheat in 2021-22 is around INR 27.04/ kg, while the Central issue price of wheat (the price at which the state governments procure wheat for NFSA) is INR 2/ kg, indicating a subsidy of approximately INR 25/ kg. This results in a structural fiscal deficit that is always greater than the fiscal allocation of the Central government, and the shortfall is made up for by borrowing, which the High-Level Committee on Restructuring of FCI (Shanta Kumar Committee) has noted to be unsustainable from 2015 onwards (Government of India, 2015). There are a few issues known as principal-agent failures within the FCI system. The Shanta Kumar Committee estimated diversion of foodgrains in PDS through ghost beneficiaries, spurious ration cards, and diversion between states and open markets at 36-47% of the foodgrains meant for the poor. Such diversions have been minimized but not eliminated by subsequent digitization initiatives like ‘One Nation One Ration Card' and biometric authentication with Aadhaar.

3.2.2. Egypt's General Authority for Supply Commodities (GASC)

There are two parallel systems of food security in Egypt: one is the TAMWEEN rationing system, which supplies subsidized cooking oil, sugar, and selected commodities to some 70 million registered beneficiaries; and the other is the Baladi bread subsidy, which allocates a flat subsidy rate per loaf through some 17,000 government bakeries. International procurement is the preserve of the General Authority for Supply Commodities (GASC) while domestic distribution logistics are coordinated by the same entity. Egypt is the biggest wheat importer in the world.

The case of Egypt's subsidy for bread is of special interest. Since Nasser's time, the Egyptian government has had a policy that keeps bread prices low; the 1977 Bread Riots, triggered after a brief liberalization attempt during the President Sadat era, which resulted in the killing of dozens and in cities all over Egypt having to endure fighting lasting for several weeks, remain a constitutive memory for the Egyptian economic policy makers and makes bread price increases a gesture of the impossible that successive governments have been trying to achieve since then (Lorenzon, 2016). This path dependence is so deep that the fiscal reform efforts of the President Al-Sisi's government that have reduced energy subsidy levels within an IMF program for the period 2016-2019 maintained the subsidy on bread in its nominal form but rather compressed the supply chain and reduced the bread quality IMF, 2022).

3.3. Political capture-rent seeking in procurement

The rent generated in procurement systems is quite high: the rent is the difference between the fixed procurement price and the market clearing price, which is a transfer from the taxpayer to the farmer; the rent is the logistics companies are charging, which is a transfer to the farmer from the taxpayer, as a result of storage and transportation contracts; the rent is the rationing agent's or fair price shop's license, which is a valuable economic privilege for the holders. All these streams of rents give political capture an incentive.

PASSCO and provincial food departments' procurement of wheat has also been repeatedly found to be riddled with political favoritism in the awarding of storage and milling contracts in Pakistan, as reported in the Parliamentary Standing Committee’s reports on wheat procurement in 2019–20 and 2020–21 in the country, which noted ‘systematic irregularities’ (Senate of Pakistan Standing Committee on National Food Security, 2021). The political economy of wheat procurement is further complicated by the federal structure of Pakistan: being a provincial subject, four provincial food departments are simultaneously engaged in wheat procurement in the same commodity market, which results in 'coordination failures' and opportunities for intergovernmental bargaining with the large traders, who can exploit such conditions through their strategic inventory management.

Governance Diagnosis: Procurement System Failures

1. There are three governance pathologies that hinder the effectiveness of procurement systems in developing economies: There are opportunities for leakage, ghost beneficiaries and contract manipulation due to information asymmetry between central agencies and field-level agents.

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2. Political interference in price-setting and in listing beneficiaries leads to biased incentives and undermines the credibility of implementing agencies in the eyes of the public from a technical point of view.

3. Poor grievance and audit systems limit the transparency and accountability of procurement processes, and result in governance failures that remain even if they are identified by senior decision makers.

4. Price Controls, Market Regulation, and Distributional Effects

4.1. Theoretical Framework: Price Controls and Welfare

Price controls (both ceiling prices in the retail market and floor prices at the farm gate) are different types of food policy instruments from input subsidies or procurement (Samaratunga *et al*., 2019). Price controls work directly interfering with the clearing mechanism of the market; the welfare effects of price controls depend on the elasticities of supply and demand, the efficient enforcement of the price controls, and the extent to which second-round effects on supply, quality, and market development are captured in the evaluation.

Basic welfare economics would suggest that a retail price ceiling below the equilibrium price will result in a consumer surplus gain (for consumers who are able to obtain the retail item at the controlled price) and a producer surplus loss (for producers who sell the item at the controlled price) while the dead weight loss will be the result of the quantity loss, defined as the difference between quantity demanded at the controlled price and quantity supplied. The practical application of the welfare calculus in developing country circumstances is much more complicated. In principle, price controls can benefit welfare in markets where it is difficult to find buyers and sellers, the number of firms is limited, and prices fluctuate quickly. In markets where it is difficult to find buyers and sellers, the number of firms is limited and prices fluctuate quickly, price controls can in principle benefit welfare by constraining monopoly rents and by providing price stability. The policy challenge is how to design interventions to achieve these benefits without producing the “supply”, “quality”, and “informal market” impacts that are counterproductive.

4.2. Evidence on Retail Price Controls in Developing Economies

4.2.1. Urban bias and distributional paradox

All three regimes of retail controls on staple foodstuffs (controlled food prices in Pakistan, bread subsidies in Egypt, and rice price ceilings in Indonesia) have a similar distributional feature: they benefit disproportionately the urban consumers who have better access to regulated markets and less reliance on their own production. This was a structural characteristic of political economy in low-income countries identified by Michael Lipton in his seminal analysis of 'urban bias' (Lipton, 1977) in development policy: urban constituencies, including the urban poor, public employees and the military, tend to be more concentrated, politically mobilizable and less able to cope with rising food prices, whereas rural smallholders were dispersed, less organized and more easily controlled through price adjustments to procurement.

The welfare paradox of retail price controls is that they benefit the highest consumers the most (those who live in cities), in terms of percentage of consumption of controlled staples, and they benefit the lowest consumers the least (those who live in rural smallholder households), both as consumers of controlled and as producers of controlled commodities, whose market returns are depressed by the price controls. The lowest quintile of households in Egypt received only 17% of the value of the subsidy on bread while the top two quintiles received 42% (Sdralevich *et al*., 2014).

4.2.2. Restrictions on exporting as price controls

Price controls via export bans and restrictions are often overlooked in economic analysis but are a common feature of the price control toolkit. Governments that restrict or tax exports of basic commodities will keep the domestic price stable at the expense of lower returns to the farmers. More than 30 countries have implemented export restrictions or bans on wheat, rice, maize or vegetable oils during the 2007-08 global food price crisis (Martin & Anderson, 2012).

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Table 6.3: Welfare Implications of Major Price Control Instruments in Developing Economies

Country	Cost	Long term effect	Short term effect	Policy
Pakistan & Egypt	Very high	Negative (producer discouragement)	Moderate – High	Price controlling (Bread)
Bangladesh & India	High	Positive (High production)	Low-Moderate	Support price at farm gate
Ethiopia & Nigeria	Moderate	Mixed (supply dependent)	Moderate (input access)	Price control (inputs)
Brazil & Mexico	Moderate	Neutral – Positive	High (Targeted)	Targeted vouchers of conditional cash transfer (CCT)
India & Indonesia	Low - Moderate	Negative (Farmer revenue)	Moderate (Urban residents)	Export restrictions

Source: Martin & Anderson (2012); Ivanic & Martin (2014); Sdralevich *et al*. (2014); World Bank (2023). Note: Effects are indicative; magnitudes vary by country context.

An estimated 18-22 million metric tonnes of rice have not been exported due to export restrictions imposed in 2022 and renewed in 2023 to address production shortfalls projected due to El Niño in the country, which has led to price volatility in the world market and kept prices in the country well below export parity (FAO, 2023).

4.3. Social Inclusion and the Social Economy

One aspect of the price control analysis that is rarely discussed is the linkage between formal price controls and informal market development. If prices are controlled and the supply is not great enough to cope with the demand, an informal market exists in parallel, which enables the prices to move towards the free market level. Formal and informal controlled markets have been observed in various parts of the food economy in Egypt (unofficial bread trade is common around Baladi bakeries), in Pakistan (flour is sold officially at higher prices and at the same level in the shadow market around local mills), and Nigeria (black-market premia of 50-100% above official prices in fertilizer markets have been observed during periods of supply shortfall) (Lorenzon, 2016; Jayne & Rashid, 2013; Hatzenbuehler *et al*., 2017).

The welfare consequences of this dual market are not clear. The controlled price is pure rent in well-connected households where they have access to formal channels. Poor households that cannot reach formal markets for any of a variety of reasons – be it geographic distance from rationing outlets; lack of documentation of eligibility; or informal exclusion by the shopkeeper because he or she prefers to sell to less poor customers – pay the market rate for food, the controlled price of which is irrelevant. Research in urban Bangladesh and rural Pakistan has revealed that the proportion of poor households who do buy from formal subsidized outlets is frequently less than 30%, and most of the poor buy from the market at uncontrolled prices (Ahmed *et al*., 2013; Rashid *et al*., 2014).

4.4. Price Stabilization vs. Long-Run Market Development

One of the key policy dilemmas, and an inherent conflict, is short-term price stabilization concerns (which tend to favor active policy making by government) and longer-term concerns regarding market development (which tend to argue for a reduction of policy intervention and growth of private sector storage, logistics and risk management capacity). Buffer stocks and preparedness to release stocks at a controlled price by governments crowd out the market and private sector's incentive to invest in the market and provide storage facilities. Several South and Southeast Asian economies have had their grain markets dependent for long periods of time on price controls that have hindered development of the private grain markets, and these have proven very difficult to unwind (Timmer, 2010).

5. Policy Reforms and Future Directions for Food Security

5.1. The Political Economy of Reform: Conditions and Constraints

Political barriers to food subsidy and price control reform are significant, in part because of the concentrated nature of the benefits. Political barriers to reform of entrenched food subsidy and price control systems are significant because of the concentrated nature of the benefits. The political economy literature suggests that

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fiscal crisis (that makes a strong argument for budget rationalization), strong technocratic capacity in the reform agencies, supportive international financial institution (IFI) involvement (both technically and politically), powerful social protection alternatives that can reduce the welfare cost to the poor of subsidy dismantling, and political leadership with will to suffer short-term electoral costs for long-term fiscal stability are among the conditions associated with successful reform episodes (Williamson, 1994; Krueger *et al*., 1988).

Most of these conditions do not exist at once in most developing economies and literature warns against universalist solutions. He showed that reform initiatives in times of extreme budget constraints, when there are insufficient social protection options, are likely to result in a decline in the welfare of the poor, and in political pushback against the reform. In other words, the sequence of reform – having alternative safety nets in place first before withdrawing subsidy – is not just a technical matter but a matter of political economy (Haggard and Kaufman, 1992).

5.2. The direct benefit transfer lesson from India and Brazil

The transition from in-kind food support to cash or vouchers transfers is the most important structural change in food policy in the 21st century developing world, driven by the development of digital payment systems, biometric identification and financial inclusion. Brazil's Bolsa Familia program, which at its peak served about 14 million families and combined cash transfers with human capital conditionalities, showed that a well-designed conditional cash transfer can improve poverty targeting, decrease fiscal costs, and be associated with improved nutrition, school attendance, and maternal health outcomes (Soares *et al*., 2010). The targeting performance of the program (about 80% of benefits accruing to the bottom two income quintiles) was significantly better than other similar in-kind food support programs.

Fiscal savings from the initiative of Direct Benefit Transfer (DBT) in India, which was introduced in 2013 and seriously stepped up from 2017 with the linkage of Aadhaar biometric IDs with bank accounts of beneficiaries, are significant and well documented, due to two reasons: elimination of ghost beneficiaries and reduction of intermediary leakage. Muralidharan *et al*. (2016) had estimated that the leakages from biometric authentication in MGNREGS wage payments came down by 24.5% while the payments for genuine beneficiaries improved. The government claimed that it saved INR 140 billion per annum in the LPG subsidy program because cooking gas subsidies were transferred from direct to DBT, which resulted in the elimination of duplicate connections and ghost connections (Ministry of Petroleum and Natural Gas, 2022).

5.3. Change in the procurement systems (from command to market)

Procurement system reform is a technical and political process. As for the technical aspects, the evidence favors a shift from centralized command procurement towards decentralized approach through open market operations where the government agencies are market players, not price setters. In this model the government sets a price range in which it may purchase and sell, and the private traders may trade freely in the range, with the government only intervening at the extremes of the range to guarantee a price within the range. Rice pledging has been trialed in Thailand with limited success; BULOG in Indonesia has tried a similar scheme, but with less success, as market operations are difficult to separate from political pressure (Warr, 2011).

Politically, the procurement system needs to be managed because it involves balancing the interest of the farming sector that wants procurement prices to be higher than the market rates and the food industry that wants access to cheap government procurements. Reforms have usually needed some kind of transitional assistance or compensation for lost interests, such as continued provision of income support payments to farmers while market prices are allowed to move, or the development of commercial storage leasing to ensure that the former role of public procurement facilities is continued under private control.

5.4. The role of international institutions

World Bank, IMF and regional development banks have always had a dual role in food policy reform: as sources of conditional financing that generate short-term political space for reform, and as technical support

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to redesign the programs. In the years following the Arab Spring in Egypt, Tunisia and Morocco (2010s), where the IMF has engaged in subsidy reform, the experience shows that international assistance is best targeted to financing the social protection alternatives that allow the political viability of subsidy reform by focusing on subsidies rather than just on the political/headline terms of subsidy reduction (Sdralevich *et al*., 2014).

Major shifts in international attitudes and approaches to national food reserve policies were also triggered by the 2008 and 2010–12 global food price crises, resulting in new guidance on optimal levels and composition of emergency food reserves, the importance of separating physical buffer stocks and financial reserves for rapid market purchases, and the need for appropriate governance to ensure reserve management does not become a political patronage game (FAO, 2011). This guidance has been used to drive reform programs in Ethiopia, Rwanda, and a number of West African States, demonstrating tangible benefits in the effectiveness of crisis response (Murphy, 2010).

6. Conclusions and Recommendations

6.1. Synthesis of Key Findings

The chapter has built and applied a political economy approach to the study of agricultural subsidies, public procurement system, and price policies in developing economies. The following are the general observations that can be derived from this analysis.

Economically costly and poorly targeted food policy instruments persist for reasons that go beyond mere technical naivety or institutional naivety (Swinnen, 2018). These policies have coherent political functions because they provide clear and specific benefits to electorally important constituencies, while the costs - fiscal burden, price distortion, investment crowding out are diffused, delayed, and hidden from the political sphere. This is the political logic that no reform initiative can overlook and is likely to fail.

Second, food policy instruments are more regressive in their distribution than they would nominally appear to be. In all the reviewed country cases, the gains of subsidies, procurement price premiums, and retail price controls go primarily to better-off households, more politically connected communities, and to urban populations, compared to rural populations. These transfers may benefit the poor in name only and have little impact on their actual well-being.

Third, governance failures – leakage, "elite capture" and "principal-agent opportunism" – are not an incidental aberration of large-scale food policy programs in developing countries but a structural characteristic. The findings, of 20–47% of the value of the programs lost in the systems reviewed, are a huge loss of resources that could be added to the scope of well-targeted social protection, if recovered through better governance and finance.

Fourth, reform is politically feasible under specific conditions—fiscal stress, technical capacity, a sequenced social protection package, and political leadership—but it needs to be carefully crafted to build broad political support for addressing the interests of the distributional coalitions that support the status quo. Reform episodes are technical as well as political successes.

6.2. Policy Recommendations

Prepare recommendations for subsidy policy

Make sure that the discussion of subsidy reform is preceded by serious incidence analysis of current subsidy programs, based on nationally representative data from household surveys. Programs which are clearly regressive in incidence are better candidates for restructuring both on equity and fiscal principle. Move from universal price controls to targeted subsidy systems using vouchers delivered electronically and that cover specific groups of beneficiaries (e.g. poor smallholders, marginal farmers); to reduce leakage through the scheme or subsidy chain.

Create public accountability mechanism through developing independent fiscal monitors with responsibility to publish annual estimates of total subsidy expenditure, distributional incidence and leakage rates, which

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can generate political momentum for reform across elections. Design exit ramps for politically entrenched subsidies by offering farmers and consumers a phase-in period of transitional income support that can be maintained as markets adapt, and then phase-out over a specified multi-year period.

The Government shall implement measures to improve the procurement process by addressing the key issues stated below:

- Move away from centralized procurement monopolies and change to price band stabilization mechanisms that allow for participation in the private sector market, thereby lowering the fiscal and governance burden on state agencies and retaining the price stabilization effect.
- Develop infrastructure for beneficiary registration, including biometric registries, address verification systems and income proxies, as a first step towards better targeting in distribution programs. These investments are always justified by the fiscal returns because of reduced leakage.
- Decentralize procurement processes to the local government level wherever administrative capacity exists, bringing accountability closer to the implementation, and allowing communities to monitor the quality of distributions.
- Build a professional cadre of food policy technocrats in implementing agencies, who are meritocratically appointed and on fixed terms to ensure a consistent level of implementation throughout election cycles.
- Substitute market-wide price caps with targeted subsidies for the poor (cash transfers, food stamps, or vouchers) that provide the price subsidy to poor households without constraining market prices from fulfilling their function of allocation.
- Create automatic stabilizer mechanisms for food prices, where market interventions by the government are based on predetermined thresholds on objective price indices, not on political judgment, and thus limit the discretion for election timing of market interventions.
- Strengthen regional food commodity reserves and price information systems (suggested by ECOWAS in West Africa and SAARC in the South Asian region) to minimize the need for single country price interventions that have regional spillovers and disrupt regional food systems. Evaluate and extend trade restrictions against domestic welfare impacts and notify WTO under an explicit sunset clause.

6.3. Looking Ahead: Food security in a changing world

Political economy of food policy in developing economies is changing rapidly due to the compounding pressures of climate change, demographic transition, digital technology and changing international trade rules. The price stabilization policy is becoming more important and there is also a premium on adaptive governance systems because climate change is exacerbating production shocks. Demographic pressure (with an estimated 1.2 billion additional people in developing economies by 2040, mainly in urban areas, is putting political pressure on the political economy from rural agricultural interests to urban consumer interests, thus creating political space for food subsidy reform. Digital technology is now improving the potential for targeted social protection delivery, as, in the past, such delivery has been less feasible than universal subsidies due to informational and logistical problems.

The enabling trends are offset by the risks of food price volatility as a consequence of climate change, its political salience, and possibly the creation of new constituencies for price stabilization; of geopolitical disruptions in global commodity trade, their impact on the credibility of market-based solutions in the eyes of policy makers; and of political polarization, which could narrow the technocratic space for policy reform.

That point, which is the core of this chapter, is that simply designing technically good instruments is not enough to create sustainable, equitable, and fiscally responsible food security policy in developing economies; it is necessary to understand the political economy context in which policy is made. However technically sound the reforms are, they will fail if these are not considered, as they will be influenced by the distributional coalitions, institutional path dependences and electoral incentives that define food policy. The ones who involve these realities have a much better chance of succeeding in creating lasting improvements in food security for the world's most vulnerable people by designing pathways of reform that carefully

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manage the vested interests, coordinate transitions and create coalitions of political players to bring change about.

References

Ahmed, A. U., Quisumbing, A. R., Nasreen, M., Hoddinott, J. F., & Bryan, E. (2013). *Comparing food and cash transfers to the ultra-poor in Bangladesh* (IFPRI Research Monograph No. 63). International Food Policy Research Institute. https://cgspace.cgiar.org/server/api/core/bitstreams/36005ac4-fdaa-4628-b809-089ad980accc/content

Bates, R. H. (1981). *Markets and states in tropical Africa: The political basis of agricultural policies*. University of California Press.

Bates, R. H. (2008). *When things fell apart: State failure in late-century Africa*. Cambridge University Press.

Birner, R., & Resnick, D. (2010). The political economy of policies for smallholder agriculture. *World Development*, *38*(10), 1442–1452. https://doi.org/10.1016/j.worlddev.2010.06.001

Chirwa, E., Dorward, A., Kachule, R., Kumwenda, I., Kydd, J., Poole, N., Poulton, C., & Stockbridge, M. (2005). Walking tightropes: Supporting farmer organisations for market access. *Natural Resource Perspectives*, *99*, 1–4. Overseas Development Institute. https://odi.org/en/publications/walking-tightropes-supporting-farmer-organisations-for-market-access/

Comptroller and Auditor General of India. (2022). *Report on food subsidies and public distribution system* (Report No. 14 of 2022). Ministry of Finance, Government of India. https://cag.gov.in/en/audit-report/details/117812

de Gorter, H., & Swinnen, J. (2002). Political economy of agricultural policy. In B. L. Gardner & G. C. Rausser (Eds.), *Handbook of agricultural economics* (Vol. 2, pp. 1893–1943). Elsevier. https://doi.org/10.1016/S1574-0072(02)10023-5

de Krom, M. P., & Muilwijk, H. (2019). Multiplicity of perspectives on sustainable food: Moving beyond discursive path dependency in food policy. *Sustainability*, *11*(10), 2773. https://doi.org/10.3390/su11102773

Dev, S. M. (2024). Regional dimensions in India: Economic growth, inclusive and sustainable development. *Journal of Quantitative Economics*, *22*(2), 245–296. https://doi.org/10.1007/s40953-024-00403-z

Dorosh, P. A., & Salam, A. (2008). Wheat markets and price stabilization in Pakistan: An analysis of policy options. *The Pakistan Development Review*, *47*(1), 71–87. https://file.pide.org.pk/pdf/PDR/2008/Volume1/71-87.pdf

Dorward, A., & Chirwa, E. (2011). The Malawi agricultural input subsidy program: 2005/06 to 2008/09. *International Journal of Agricultural Sustainability*, *9*(1), 232–247. https://doi.org/10.3763/ijas.2010.0567

Dreze, J., & Khera, R. (2015). Understanding leakages in the public distribution system. *Economic and Political Weekly*, *50*(7), 39–42. https://www.ideasforindia.in/topics/poverty-inequality/balancing-corruption-and-exclusion-comment-on-the-response

Food and Agriculture Organization of the United Nations. (2022). *World food and agriculture – Statistical yearbook 2022*. https://openknowledge.fao.org/server/api/core/bitstreams/0c372c04-8b29-4093-bba6-8674b1d237c7/content

Food and Agriculture Organization of the United Nations. (2023). *Cereal supply and demand brief, October 2023*. https://www.fao.org/worldfoodsituation/csdb/en

Government of India. (2015). *Report of the high-level committee on reorienting the role and restructuring of Food Corporation of India* (Shanta Kumar Committee Report). https://www.isaeindia.com/view-pdf/9

Gulati, A., & Banerjee, P. (2015). *Rationalising fertiliser subsidy in India: Key issues and the way forward* (Working Paper No. 307). Indian Council for Research on International Economic Relations. https://www.econstor.eu/bitstream/10419/176325/1/icrier-wp-307.pdf

Haggard, S., & Kaufman, R. R. (1992). *The politics of economic adjustment*. Princeton University Press.

Hatzenbuehler, P. L., Abbott, P. C., & Abdoulaye, T. (2017). Price transmission in Nigerian food security crop markets. *Journal of Agricultural Economics*, *68*(1), 143–163. https://doi.org/10.1111/1477-9552.12169

International Monetary Fund. (2022). *Arab Republic of Egypt: Third review under the extended arrangement under the extended fund facility* (IMF Country Report No. 22/279). https://doi.org/10.5089/9798400288869.002

International Monetary Fund. (2023). *Fiscal monitor: Climate and debt*. https://www.imf.org/en/publications/fm

Ivanic, M., & Martin, W. (2014). *Short- and long-run impacts of food price changes on poverty* (Policy Research Working Paper No. 7011). World Bank. https://documents1.worldbank.org/curated/en/106581468325435880/pdf/WPS7011.pdf

Jacoby, H. G. (2016). Food prices, wages, and welfare in rural India. *Economic Inquiry*, *54*(1), 159–176. https://doi.org/10.1111/ecin.12237

Jayne, T. S., & Rashid, S. (2013). Input subsidy programs in sub-Saharan Africa: A synthesis of recent evidence. *Agricultural Economics*, *44*(6), 547–562. https://doi.org/10.1111/agec.12073

Kherallah, M., Delgado, C., Gabre-Madhin, E., Minot, N., & Johnson, M. (2002). *Reforming agricultural markets in Africa* (IFPRI Food Policy Statement No. 38). International Food Policy Research Institute.

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Krueger, A. O., Schiff, M., & Valdes, A. (1988). Agricultural incentives in developing countries: Measuring the effect of sectoral and economywide policies. *The World Bank Economic Review*, *2*(3), 255–271. https://doi.org/10.1093/wber/2.3.255

Lipton, M. (1977). *Why poor people stay poor: Urban bias in world development*. Harvard University Press.

Lorenzon, F. (2016). The political economy of food subsidies in Egypt: Reforms and strengthening of social protection. *The Public Sphere: Journal of Public Policy*, *4*(1). https://psj.lse.ac.uk/articles/44

Martin, W., & Anderson, K. (2012). Export restrictions and price insulation during commodity price booms. *American Journal of Agricultural Economics*, *94*(2), 422–427. https://doi.org/10.1093/ajae/aar105

Ministry of Consumer Affairs, Food & Public Distribution, Government of India. (2022). *Annual report 2021–22*. https://www.chinimandi.com/wp-content/uploads/2022/08/1sGbO2W68mUlunCgKmpnLF5WHm_pdf_FOOD_Annual-Report_2021-2022-Final_New.pdf

Ministry of Finance, Government of India. (2022). *Union budget documents 2022–23*. https://prsindia.org/budgets/parliament/union-budget-2022-23-analysis

Ministry of Petroleum and Natural Gas, Government of India. (2022). *Annual report 2021–22*. https://www.fipi.org.in/assets/pdf/Annual_Report2021-22.pdf

Muralidharan, K., Niehaus, P., & Sukhtankar, S. (2016). Building state capacity: Evidence from biometric smartcards in India. *American Economic Review*, *106*(10), 2895–2929. https://doi.org/10.1257/aer.20141346

Murphy, S. (2010). *Trade and food reserves: What role does the WTO play*. Institute for Agriculture and Trade Policy. https://www.files.ethz.ch/isn/121654/2010-09-Trade-and-Food-Reserves.pdf

North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge University Press.

Organisation for Economic Co-operation and Development. (2023). *Agricultural policy monitoring and evaluation 2023*. https://www.oecd.org/en/publications/2023/10/agricultural-policy-monitoring-and-evaluation-2023_7cc05c6a.html

Olson, M. (1965). *The logic of collective action: Public goods and the theory of groups*. Harvard University Press.

Olson, M. (1982). *The rise and decline of nations: Economic growth, stagflation, and social rigidities*. Yale University Press.

Pierson, P. (2000). Increasing returns, path dependence, and the study of politics. *American Political Science Review*, *94*(2), 251–267. https://doi.org/10.2307/2586011

Pinstrup-Andersen, P. (1988). *Food subsidies in developing countries: Costs, benefits, and policy options*. IFPRI/Johns Hopkins University Press. https://hdl.handle.net/10568/161090

Rashid, S., Dorosh, P., & Malek, M. (2014). Modern input promotion in sub-Saharan Africa: Insights from Asian green revolution. *Agricultural Economics*, *45*(S1), 77–89. https://doi.org/10.1111/agec.12083

Samaratunga, P., Punjabi, M., Karmacharya, B., & Balakrishnan, U. (2019). Agricultural pricing and procurement policies in South Asia. *Gates Open Research*, *3*, 665. https://doi.org/10.21955/gatesopenres.1115488.1

Sdralevich, C., Sab, R., Zouhar, Y., & Carvalho, G. (2014). *Subsidy reform in the Middle East and North Africa: Recent progress and challenges ahead* (IMF Middle East and Central Asia Departmental Papers No. DP/14/08). International Monetary Fund. https://www.imf.org/-/media/websites/imf/imported-publications/external/pubs/ft/dp/2014/_1403mcdsum.pdf

Senate of Pakistan Standing Committee on National Food Security and Research. (2021). *Report on wheat procurement irregularities 2019–20 and 2020–21*. Senate Secretariat of Pakistan.

Soares, F. V., Ribas, R. P., & Osório, R. G. (2010). Evaluating the impact of Brazil's Bolsa Família: Cash transfer programmes in comparative perspective. *Latin American Research Review*, *45*(2), 173–190. https://www.cambridge.org/core/journals/latin-american-research-review/article/evaluating-the-impact-of-brazils-bolsa-familia-cash-transfer-programs-in-comparative-perspective/886D3D2634B431B0D19054F12CA58167

Swinnen, J. (2018). The political economy of agricultural and food policies. In *The Routledge handbook of agricultural economics* (pp. 381–398). Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9781315623351-21/political-economy-agricultural-food-policies-johan-swinnen

Timmer, C. P. (2010). Reflections on food crises past. *Food Policy*, *35*(1), 1–11. https://doi.org/10.1016/j.foodpol.2009.09.002

United Nations. (1948). *Universal declaration of human rights* (General Assembly Resolution 217[III]).

United Nations. (1966). *International covenant on economic, social and cultural rights* (Treaty Series Vol. 993). https://www.ohchr.org/en/instruments-mechanisms/instruments/international-covenant-economic-social-and-cultural-rights

Varshney, A. (1998). *Democracy, development, and the countryside: Urban-rural struggles in India*. Cambridge University Press.

Warr, P. (2011). Food insecurity and its determinants. *Australian Journal of Agricultural and Resource Economics*, *55*(4), 526–548. https://doi.org/10.1111/1467-8489.12073

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Williamson, J. (1994). *The political economy of policy reform*. Institute for International Economics.
World Bank. (2023). *World development indicators*. World Bank Group. https://datatopics.worldbank.org/world-development-indicators/

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CHAPTER 07

Marine Food Security Challenges and Policy Responses in Developing Countries: Comparative Evidence from Indonesia, India, and Tanzania

La Ode M. Aslan[1],*, Tamrin[2], Wa Kuasa Baka[3], Siti Aida Adha Taridala[4], Usman Rianse[5], Yusuf Sabilu[6] & Ratna Diyah Palupi[7]

[1] Department of Aquaculture, Faculty of Fisheries and Marine Sciences, Halu Oleo University, Kendari 93232, Indonesia
[2] Department of Food Science and Technology, Faculty of Agriculture, Halu Oleo University, Kendari 93232, Indonesia
[3] Department of Oral Tradition, Faculty of Cultural Sciences, Halu Oleo University, Kendari 93232, Indonesia
[4] Department of Agribusiness, Faculty of Agriculture, Halu Oleo University, Kendari 93232, Indonesia
[5] Department of Agribusiness, Faculty of Agriculture, Halu Oleo University, Kendari 93232, Indonesia
[6] Public Health Study Program, Faculty of Public Health, Halu Oleo University, Kendari 93232, Indonesia
[7] Department of Marine Science, Faculty of Fisheries and Marine Sciences, Halu Oleo University, Kendari 93232, Indonesia

Corresponding author's email: laodemaslan@uho.ac.id

Abstract

Marine food systems are a critical component of global food and nutrition security, providing essential animal protein, micronutrients, livelihoods, and economic opportunities for hundreds of millions of people, particularly in developing coastal and island nations. Despite their significance, they remain underrepresented in conventional food security assessments, which are largely centered on terrestrial agriculture. Growing demand for nutrient-rich "blue foods" and the relatively low environmental footprint of aquatic foods have increased the strategic importance of marine resources in sustainable food system transitions. However, marine food systems face mounting challenges from overfishing, habitat degradation, pollution, climate change, and weak governance structures that undermine sustainable resource management and equitable access. Climate-induced changes in ocean temperatures and fish distribution patterns, combined with illegal, unreported, and unregulated (IUU) fishing, further threaten food security and livelihoods, particularly in the Global South. Comparative evidence from Indonesia, India, and Tanzania highlights shared structural constraints, including ecological stress, institutional weaknesses, and unequal access to marine resources, despite differing national contexts. At the same time, ecosystem-based fisheries management, improved aquaculture governance, climate adaptation strategies, and the expansion of sustainable seaweed farming offer promising pathways toward resilience and inclusive blue economy development. This chapter proposes the Global Marine Food Security Index (GMFSI) as an integrated conceptual framework linking ecological sustainability, nutritional outcomes, and socio-economic dimensions to better assess and guide marine food security policies. Ensuring the long-term sustainability of marine food systems will require coordinated, cross-sectoral governance approaches that prioritize environmental integrity, climate resilience, and social equity.

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1. Introduction

Food and nutrition security remains one of the most persistent and structurally complex challenges in global development. Despite long-term gains in agricultural productivity and sustained international interventions, progress toward eliminating hunger and malnutrition has been uneven and insufficient. Current estimates indicate that approximately 673 million people, about 8.2% of the global population experienced hunger in 2024, while more than 2.3 billion faced moderate or severe food insecurity (FAO, IFAD, UNICEF, WFP, & WHO, 2025). These figures expose a structural imbalance in global food systems in which aggregate

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availability coexists with persistent inequities in access, affordability, and nutritional adequacy. Reinforcing this concern, nearly one-third of the global population remains unable to afford a healthy diet, underscoring that food insecurity is increasingly driven by economic constraints and distributional inefficiencies rather than absolute production shortfalls (FAO *et al*., 2025).

The burden of malnutrition further complicates this picture. Undernutrition, micronutrient deficiencies, and overweight and obesity now coexist within countries and even within households, particularly across low- and middle-income settings. Deficiencies in essential micronutrients including iron, zinc, iodine, vitamin A, and vitamin B12 continue to undermine cognitive development, immune function, and labor productivity (Development Initiatives, 2024). At the same time, demographic expansion is placing additional pressure on food systems, with the global population projected to reach 9.7 billion by 2050 (United Nations, 2024). Depending on dietary trajectories and socioeconomic pathways, global food demand may increase by 35–56% by mid-century (van Dijk *et al*., 2021), intensifying pressure on already constrained land, water, and ecosystem resources.

Terrestrial food systems, which dominate global supply, are increasingly approaching ecological limits. Agricultural expansion and intensification continue to drive deforestation, biodiversity loss, freshwater depletion, and greenhouse gas emissions, contributing to widespread transgression of planetary boundaries (Campbell *et al*., 2017; Crippa *et al*., 2021). Climate change further exacerbates these pressures by altering temperature regimes, disrupting precipitation patterns, and increasing the frequency of extreme events. The Intergovernmental Panel on Climate Change (IPCC, 2023) confirms that yields of major staple crops such as rice, wheat, and maize are already declining in vulnerable regions. Collectively, these dynamics highlight the diminishing capacity of conventional land-based systems to sustain future food demand.

Within this context, aquatic food systems commonly referred to as “blue foods” have gained recognition as a critical complement to terrestrial production. These include finfish, shellfish, crustaceans, mollusks, and seaweeds derived from marine and freshwater ecosystems. Relative to many terrestrial animal protein systems, aquatic foods often require less land and freshwater and generate lower greenhouse gas emissions across several production pathways (Costello *et al*., 2023). Nutritionally, they are rich in highly bioavailable protein, essential amino acids, omega-3 fatty acids, and key micronutrients such as iron, zinc, iodine, calcium, selenium, and vitamin B12 (Hicks *et al*., 2019; Golden *et al*., 2021), making them particularly relevant for addressing persistent “hidden hunger.”

This importance is reflected in global production trends. In 2022, fisheries and aquaculture output reached 223.2 million tonnes, with aquaculture surpassing capture fisheries as the dominant source of fish for human consumption (FAO, 2024). This shift signals a structural transformation in global food systems and positions aquaculture as a central pillar of future food security. Beyond nutrition, the sector supports the livelihoods of approximately 600 million people through employment and value-chain activities, while small-scale fisheries remain especially vital for food security, income generation, and social cohesion in developing regions (Béné *et al*., 2016).

These developments have catalyzed broader “blue economy” approaches that integrate ecological sustainability with economic and social objectives. Evidence suggests that well-managed expansion of aquatic food systems can improve nutritional outcomes while reducing environmental pressures associated with terrestrial agriculture (Golden *et al*., 2021; Costello *et al*., 2023). However, realizing this potential requires addressing persistent governance deficits, ecological degradation, and structural inequalities that continue to constrain marine food systems, particularly in developing countries.

Within the Global South, marine food systems occupy a strategically central role. Indonesia, India, and Tanzania illustrate this dependence in distinct but complementary ways: Indonesia as a leading archipelagic seaweed producer, India as a rapidly expanding aquaculture economy, and Tanzania as a coastal system reliant on small-scale fisheries and seaweed farming. Despite contextual differences, these countries face converging challenges, including climate impacts, resource overexploitation, governance limitations, and heightened coastal vulnerability (Allison *et al*., 2009; IPCC, 2023). Comparative analysis therefore offers a robust basis for identifying transferable policy insights.

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In this framework, marine food security is conceptualized as a multidimensional construct encompassing nutritional adequacy, ecological sustainability, economic viability, and institutional resilience. This integrated perspective underpins the proposed Global Marine Food Security Index (GMFSI), designed to support comparative assessment and evidence-informed policymaking across marine food systems.

1.1. Why Marine Food Security Matters for Developing Countries

Marine food security has become increasingly important for developing countries because of its direct contribution to food availability, nutrition, employment, poverty alleviation, and economic development. Across much of the Global South, marine and aquatic resources constitute a fundamental component of national food systems and support the livelihoods of hundreds of millions of people. Unlike many industrialized countries, where aquatic foods often represent a relatively small proportion of dietary intake, developing countries frequently rely on fisheries and aquaculture as primary sources of animal protein, essential micronutrients, employment opportunities, and household income (FAO, 2024; Béné *et al*., 2016). Consequently, the sustainability and resilience of marine food systems are closely linked to broader development objectives, including food security, poverty reduction, economic growth, and social stability.

The significance of marine food security is particularly evident in countries with extensive coastlines and large coastal populations. Approximately 40% of the global population lives within 100 km of the coast, with a substantial proportion residing in developing countries across Asia, Africa, and Latin America (United Nations, 2021). Coastal communities often depend directly on fisheries, aquaculture, and related marine industries for their livelihoods. In many regions, fishing activities serve not only as a source of food but also as a critical economic safety net, particularly where alternative employment opportunities are limited. The health and productivity of marine ecosystems therefore have direct implications for household welfare, income generation, and community resilience.

Marine resources are particularly important in developing countries because they provide highly nutritious foods that contribute significantly to dietary quality and public health. Fish and other aquatic foods contain high-quality protein, essential amino acids, omega-3 fatty acids, vitamins, and minerals that are vital for human growth and development (Golden *et al*., 2021). These nutritional benefits are especially important in low- and middle-income countries, where micronutrient deficiencies remain widespread and where access to diverse and nutrient-rich foods is often constrained. Aquatic foods are rich sources of iron, zinc, iodine, calcium, selenium, and vitamin B12, nutrients that are essential for cognitive development, immune function, maternal health, and child growth (Hicks *et al*., 2019; Thilsted *et al*., 2016). As a result, fisheries and aquaculture contribute not only to food security in quantitative terms but also to nutrition security by improving the quality of diets.

Recent evidence suggests that the role of aquatic foods in addressing malnutrition has been underestimated in conventional food security frameworks. Hicks *et al*. (2019) demonstrated that improved management and distribution of global fisheries resources could substantially reduce micronutrient deficiencies affecting vulnerable populations. Similarly, Golden *et al*. (2021) identified aquatic foods as one of the most promising yet underutilized solutions for addressing the interconnected challenges of malnutrition, environmental sustainability, and livelihood security. These findings are particularly relevant for developing countries, where dietary deficiencies often coexist with limited access to healthcare and other social services.

Beyond their nutritional contribution, fisheries and aquaculture represent major sources of employment and income. According to FAO (2024), approximately 62 million people were directly engaged in fisheries and aquaculture production worldwide in 2022, while hundreds of millions more depended on associated value chains involving processing, transportation, marketing, and trade. Importantly, around 90% of those directly employed in capture fisheries work in small-scale fisheries, the vast majority of whom are located in developing countries (FAO, 2024). The sector therefore plays a crucial role in supporting rural and coastal livelihoods, particularly among economically vulnerable populations.

Small-scale fisheries occupy a central position within marine food systems throughout the Global South. These fisheries are characterized by labor-intensive operations, relatively low capital investment, and strong

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links to local food systems and community livelihoods. Although frequently overlooked in national economic statistics, small-scale fisheries contribute significantly to food security, employment, and cultural identity in many developing countries (HLPE, 2014). They provide a substantial share of fish consumed domestically and often supply local markets with affordable and nutrient-rich foods. Furthermore, small-scale fisheries support social cohesion and community resilience by maintaining traditional knowledge systems and fostering local resource stewardship.

The importance of small-scale fisheries extends beyond direct food production. They serve as critical livelihood buffers during periods of economic instability, environmental shocks, and agricultural failures. In many coastal regions, fishing households rely on diversified livelihood strategies that combine fishing with agriculture, aquaculture, trading, and seasonal labor. This diversification enhances household resilience and reduces vulnerability to external shocks (Allison & Ellis, 2001). Consequently, strengthening small-scale fisheries can contribute simultaneously to food security, poverty reduction, and climate adaptation objectives.

Marine food systems also play a significant role in reducing poverty across developing countries. Fisheries and aquaculture generate income opportunities for some of the world's poorest populations, including small-scale fishers, fish farmers, processors, traders, and transport workers. Béné *et al*. (2016) argue that fisheries contribute to poverty reduction through three principal pathways: direct income generation, provision of affordable food, and broader economic multiplier effects within coastal economies. Income generated from fisheries activities supports household expenditures on food, education, healthcare, and housing, thereby contributing to improved welfare outcomes.

In many developing countries, marine resources also represent important sources of foreign exchange earnings and economic growth. Fish and seafood products are among the most widely traded food commodities globally, generating substantial export revenues for coastal nations. Aquaculture has emerged as one of the fastest-growing food production sectors worldwide and is increasingly recognized as a strategic component of sustainable economic development (FAO, 2024). Similarly, seaweed farming has become an important source of employment and export income in several countries, particularly in Indonesia (Aslan *et al*., 2018; Rahim *et al*., 2019; Ya'la *et al*., 2022) and in Tanzania (Charisiadou, . *et al*. (2022); Msuya and Hurtado, 2017; Tobisson, E. *et al*. 2021; World Bank, 2022). The expansion of sustainable aquaculture and seaweed industries therefore offers significant opportunities to strengthen marine food security while supporting inclusive economic growth.

Despite these contributions, marine food systems in developing countries face mounting pressures from climate change, overfishing, habitat degradation, pollution, and governance challenges. These threats disproportionately affect poor and marginalized coastal communities whose livelihoods depend heavily on marine resources (Allison *et al*., 2009; IPCC, 2023). Rising ocean temperatures, changing fish distributions, extreme weather events, and declining ecosystem health are increasing the vulnerability of fisheries-dependent populations and threatening the long-term sustainability of marine food supplies. Strengthening marine food security therefore requires integrated policy approaches that simultaneously address environmental sustainability, socioeconomic development, and institutional resilience.

Taken together, these considerations highlight the central role of marine food systems in the development trajectories of countries across the Global South. Fisheries, aquaculture, and other marine-based activities provide food, nutrition, employment, income, and economic opportunities for millions of people while supporting broader goals related to poverty reduction, social inclusion, and sustainable development. As pressures on terrestrial food systems intensify and demand for nutritious foods continue to grow, marine food security will become increasingly important as a pillar of resilient and sustainable food systems in developing countries.

1.2. Comparative Rationale: Indonesia, India, and Tanzania

The selection of Indonesia, India, and Tanzania as comparative case studies provides a valuable opportunity to examine the diverse challenges and opportunities associated with marine food security across the Global

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South. Although these countries differ considerably in terms of geography, population size, economic structure, governance capacity, and levels of technological development, they share a common dependence on marine and aquatic resources for food security, employment, income generation, and socioeconomic development. Collectively, they represent three distinct yet interconnected marine socio-ecological systems in Southeast Asia, South Asia, and East Africa, thereby offering important insights into how developing countries can strengthen marine food security under conditions of environmental change, population growth, and increasing resource pressures (Allison *et al*., 2009; FAO, 2024).

A comparative approach is particularly valuable because marine food security is shaped by multiple interacting factors, including ecological conditions, fisheries productivity, aquaculture development, governance effectiveness, market integration, and social vulnerability. By examining countries with different resource endowments and policy experiences, it becomes possible to identify both context-specific challenges and broadly applicable policy solutions. Comparative analysis also facilitates cross-country learning regarding sustainable fisheries management, aquaculture expansion, climate adaptation, blue economy development, and community-based resource governance (Cinner *et al*., 2012; World Bank, 2017).

Indonesia: A Global Maritime Nation and Seaweed Powerhouse

Indonesia represents one of the world's most significant marine nations. As the largest archipelagic state, the country comprises 17,380 islands (Badan Informasi Geospasial, 2024) and possesses one of the longest coastlines globally, extending approximately 108,000 km ((Badan Informasi Geospasial, 2018). Its marine territory encompasses highly productive ecosystems, including coral reefs, mangroves, seagrass meadows, estuaries, and extensive coastal waters that support exceptional marine biodiversity (Ministry of Marine Affairs and Fisheries, 2024).

The fisheries sector plays a crucial role in Indonesia's economy and food system. Indonesia consistently ranks among the world's largest fish-producing countries, contributing substantially to both capture fisheries and aquaculture production. According to FAO (2024), Indonesia remains one of the leading global producers of aquatic foods, supplying domestic markets while also generating significant export revenues. Fish consumption has increased steadily over the past two decades, reflecting the growing importance of aquatic foods in improving national nutrition and food security.

Indonesia is also recognized as the world's leading producer of tropical seaweed, particularly species belonging to the genera *Kappaphycus* and *Eucheuma*, which are widely ued in carrageenan production. Seaweed farming has become a major livelihood activity in many coastal communities (Aslan e al., 2022; 2024), generating employment opportunities, supporting export earnings, and contributing to poverty reduction in rural coastal areas (FAO, 2024). The strategic importance of seaweed extends beyond economic benefits, as it represents a highly sustainable source of nutritious food and an important component of emerging blue food systems. Nevertheless, Indonesia continues to face significant challenges related to overfishing, illegal, unreported and unregulated (IUU) fishing, habitat degradation, climate change impacts, and governance complexities associated with managing vast marine territories (OECD, 2023).

India: Expanding Fisheries Production and the Blue Economy Agenda

India represents another critical case study because of its large population, extensive coastline, and rapidly growing fisheries and aquaculture sectors. With a coastline approximately 11,098 km (Government of India, 2025) and a population surpassing 1.4 billion people, India faces substantial challenges in ensuring food and nutrition security while maintaining sustainable resource use (Government of India, 2024).

The fisheries sector plays a significant role in supporting livelihoods, food supply, and economic development. India ranks among the world's largest producers of fish and aquaculture products, with inland aquaculture and shrimp farming experiencing particularly rapid growth over recent decades (FAO, 2024). The sector supports millions of fishers, fish farmers, processors, traders, and associated workers, making it a vital source of employment and income generation. Fish also constitute an important source of animal protein and micronutrients for many households, particularly in coastal and riverine regions.

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In recent years, India has increasingly embraced the blue economy as a strategic framework for sustainable marine development. Government initiatives such as the *Pradhan Mantri Matsya Sampada Yojana* (PMMSY) seek to enhance fisheries productivity, strengthen value chains, improve infrastructure, promote sustainable aquaculture, and increase export competitiveness (Government of India, 2024). Simultaneously, India is investing in marine spatial planning, ocean-based industries, and climate-resilient fisheries management. Despite these advances, significant challenges remain, including overexploitation of marine fish stocks, coastal pollution, habitat degradation, post-harvest losses, and the vulnerability of small-scale fishing communities to climate change (FAO, 2024; Allison *et al*., 2009).

Tanzania: Coastal Livelihoods and Seaweed-Based Development

Tanzania offers an important African perspective on marine food security. Although its fisheries sector is smaller than those of Indonesia and India, marine resources play a critical role in supporting livelihoods, food security, and economic development along the country's extensive Indian Ocean coastline. Coastal communities depend heavily on fisheries and marine-related activities, particularly small-scale fisheries that provide both subsistence and commercial benefits (United Republic of Tanzania, 2024).

Small-scale fisheries dominate Tanzania's coastal economy and serve as a major source of employment, income, and food for vulnerable households. Fish constitute an important component of local diets and provide essential protein and micronutrients for many communities. However, productivity remains constrained by limited infrastructure, inadequate cold-chain facilities, post-harvest losses, and restricted access to markets and financial services (FAO, 2024).

Tanzania is also internationally recognized as one of Africa's leading seaweed-producing countries. Seaweed farming, has expanded substantially as a low-cost livelihood strategy for smallholder coastal households (Msuya, 2006; Tobisson *et al*., 2021). The sector also plays a significant socio-economic role, especially in women's employment, with women constituting the majority of producers in Zanzibar and deriving important benefits in terms of household income, welfare improvement, and livelihood security (Msuya and Hurtado, 2017; Charisiadou *et al*., 2022). However, the sustainability of the sector is increasingly constrained by multiple interacting stressors, including climate change-induced increases in sea surface temperature, disease outbreaks, and declining productivity, as well as persistent market instability and structurally weak positions within global value chains (Msuya and Porter, 2014; Tobisson *et al*., 2021). These challenges collectively undermine long-term resilience despite ongoing farmer-level adaptation strategies. Overall, seaweed farming in Tanzania reflects a duality of substantial socio-economic benefits alongside increasing ecological and economic vulnerability (World Bank, 2022; Tobisson *et al*., 2021).

Comparative Learning Opportunities

The inclusion of Indonesia, India, and Tanzania enables meaningful comparative analysis across different development contexts while maintaining a common focus on marine food systems. Indonesia provides lessons regarding large-scale fisheries management and seaweed industry development; India offers insights into aquaculture expansion and blue economy policy integration; and Tanzania highlights the role of small-scale fisheries and community-based coastal livelihoods. Together, these countries illustrate how marine food security can contribute to achieving broader objectives related to poverty reduction, nutritional improvement, climate resilience, and sustainable development.

Moreover, the three countries face many shared challenges, including climate change, marine ecosystem degradation, overexploitation of resources, governance constraints, and socioeconomic vulnerability among coastal populations. Comparative examination of these challenges and policy responses can therefore generate transferable lessons for other developing countries seeking to strengthen marine food security while advancing sustainable blue economy pathways.

1.3. Objectives and Scope of the Chapter

Marine food security is increasingly recognized as a critical component of sustainable development, particularly in developing countries where fisheries, aquaculture, and coastal ecosystems support the food

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and livelihood needs of millions of people. Despite the growing importance of aquatic foods within global food systems, significant knowledge gaps remain regarding the factors that influence marine food security and the policy interventions required to enhance its resilience under conditions of environmental and socioeconomic change. This chapter seeks to address these gaps through a comparative assessment of marine food systems in Indonesia, India, and Tanzania.

Objectives of the Chapter

The primary objective of this chapter is to examine the major challenges affecting marine food security in developing countries and to identify evidence-based policy solutions that can strengthen the sustainability and resilience of marine food systems. Specifically, the chapter aims to:

1. Examine the principal ecological, economic, social, and governance challenges affecting marine food security in Indonesia, India, and Tanzania, including climate change, overfishing, habitat degradation, post-harvest losses, market constraints, and institutional limitations.
2. Compare the structure and performance of marine food systems across the three countries, with particular attention to fisheries production, aquaculture development, seaweed farming, nutritional contributions, livelihood dependence, and socioeconomic outcomes.
3. Identify and evaluate policy solutions capable of enhancing marine food security, including ecosystem-based fisheries management, sustainable aquaculture, blue economy strategies, climate adaptation measures, marine spatial planning, community-based resource management, and technological innovation.
4. Develop a conceptual framework for Marine Food Security Assessment, capable of capturing the multidimensional interactions among ecological sustainability, food availability, accessibility, utilization, stability, governance quality, and climate resilience in developing-country contexts.

1.4. Scope of the Chapter

To achieve these objectives, the chapter adopts an interdisciplinary and comparative perspective that integrates ecological, socioeconomic, institutional, and policy dimensions of marine food systems. The analysis focuses on fisheries, aquaculture, and seaweed farming as key components of marine food security while considering broader interactions with coastal livelihoods, environmental sustainability, and blue economy development.

The chapter is structured around four interrelated dimensions of marine food security: availability, access, utilization, and stability, which are widely recognized as the foundational pillars of food security (FAO, 2008). These dimensions are examined within a broader social-ecological systems framework that recognizes the interconnected nature of marine ecosystems, human communities, governance institutions, and economic processes (Ostrom, 2009).

In addition, the chapter extends conventional food security analysis by incorporating emerging concepts such as aquatic foods, blue foods, climate resilience, ecosystem services, and blue economy transformation. Particular emphasis is placed on understanding how fisheries and aquaculture can contribute not only to food production but also to nutrition security, poverty reduction, gender inclusion, and sustainable coastal development.

Finally, the chapter proposes the development of a Global Marine Food Security Index (GMFSI) framework tailored to the realities of developing countries. Unlike conventional food security indices that focus primarily on terrestrial agricultural systems, the proposed framework explicitly incorporates marine and aquatic dimensions, including fisheries productivity, aquaculture performance, seaweed production, ecosystem health, governance effectiveness, and climate vulnerability. Such a framework has the potential to support policymakers, researchers, and development practitioners in monitoring progress, identifying vulnerabilities, and designing more effective interventions to strengthen marine food security in the Global South.

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2. Conceptual Framework of Marine Food Security and Sustainability

2.1. Defining Marine Food Security

Food security is traditionally defined as a condition in which all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2008). However, growing recognition of the contribution of aquatic foods to global nutrition, livelihoods, and sustainable development has expanded this concept to encompass marine and aquatic food systems. Marine food security can therefore be understood as the ability of marine and coastal ecosystems to sustainably provide sufficient quantities of safe, nutritious, accessible, and affordable aquatic foods while maintaining ecosystem integrity and resilience for present and future generations (HLPE, 2014; FAO, 2024). This concept broadens conventional food security frameworks by explicitly incorporating fisheries, aquaculture, seaweed farming, marine ecosystem governance, climate resilience, and blue economy principles within an integrated social-ecological system perspective (Ostrom, 2009; Golden *et al*., 2021).

The importance of marine food security has increased considerably in recent decades as aquatic foods have emerged as essential components of sustainable food systems. Fisheries and aquaculture currently provide approximately 20% of average animal protein intake for more than 3.3 billion people worldwide (FAO, 2024). Recent evidence demonstrates that aquatic foods represent one of the most effective pathways for addressing global malnutrition because of their high nutrient density and bioavailability (Golden *et al*., 2021; Hicks *et al*., 2019). Moreover, capture fisheries, aquaculture, and seaweed farming contribute substantially to livelihood security, poverty reduction, and economic development, particularly in low- and middle-income countries where coastal populations remain highly dependent on marine resources (Béné *et al*., 2016; Thilsted *et al*., 2016).

Marine food security is intrinsically linked to several broader development objectives. First, it contributes directly to food security by ensuring a stable supply of aquatic foods. Second, it supports nutrition security through the provision of nutrient-rich foods that improve dietary quality and public health outcomes (Golden *et al*., 2021). Third, marine food systems form a fundamental pillar of the blue economy by generating employment, trade opportunities, and economic growth through the sustainable use of marine resources (World Bank, 2017; OECD, 2023). Finally, marine food security depends on ecosystem sustainability because long-term fisheries productivity and aquaculture development are inseparable from the health and resilience of marine ecosystems (Duarte *et al*., 2020; Bennett *et al*., 2021). Consequently, marine food security should be viewed not merely as a food production issue but as an integrated framework linking ecological sustainability, human nutrition, economic development, and social well-being.

2.2. The Four Pillars of Marine Food Security

The conceptual foundation of marine food security is built upon the four internationally recognized pillars of food security: availability, accessibility, utilization, and stability (FAO, 2008; HLPE, 2014). These dimensions are interdependent and collectively determine the capacity of marine food systems to contribute to sustainable development and human well-being.

Availability: Availability refers to the physical supply of aquatic foods generated through capture fisheries, aquaculture, seaweed cultivation, and other marine production systems. It represents the most fundamental dimension of marine food security because adequate food supply is a prerequisite for achieving nutritional and socioeconomic outcomes. Aquaculture has become the fastest-growing food production sector globally and now exceeds capture fisheries as the primary source of aquatic foods for human consumption (FAO, 2024; Troell *et al*., 2014). Recent projections further indicate that sustainable expansion of marine food production could play a major role in meeting future food demand while reducing pressure on terrestrial food systems (Costello *et al*., 2023).

Key indicators of marine food availability include fisheries production, aquaculture output, seaweed production, fish supply per capita, and marine protein availability. Maintaining these indicators requires

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sustainable management of fish stocks, protection of critical habitats, and investments in climate-resilient production systems (FAO, 2024; Costello *et al*., 2023).

Accessibility: Accessibility refers to the ability of individuals and households to obtain aquatic foods through economic, social, and physical means. Even where aquatic foods are abundant, poverty, inadequate infrastructure, market inefficiencies, and unequal distribution systems can limit access to nutritious foods. Fisheries and aquaculture support the livelihoods of more than 600 million people worldwide, many of whom depend directly on marine resources for income and food security (FAO, 2024).

Small-scale fisheries are particularly important in developing countries because they simultaneously provide employment, household income, and access to nutritious foods for vulnerable coastal communities (Allison & Ellis, 2001; Béné *et al*., 2016). Access to aquatic foods is therefore strongly influenced by market connectivity, transportation infrastructure, cold-chain facilities, household purchasing power, and value-chain efficiency. Strengthening these components can improve food accessibility while enhancing livelihood resilience and poverty reduction outcomes (World Bank, 2023).

Utilization: Utilization concerns the nutritional quality of food consumed and the body's capacity to absorb and use nutrients effectively. This dimension emphasizes food quality rather than food quantity alone. Aquatic foods are among the most nutrient-dense foods available and provide highly bioavailable proteins, essential amino acids, omega-3 fatty acids, vitamins, and minerals that are critical for human growth, cognitive development, and immune function (Golden *et al*., 2021; Hicks *et al*., 2019).

Research has shown that improved access to aquatic foods can significantly reduce micronutrient deficiencies and improve nutrition outcomes, particularly among women and children in low-income countries (Thilsted *et al*., 2016). Seaweed also represents an increasingly important component of marine food utilization due to its high concentrations of essential micronutrients such as iodine, calcium, and iron, as well as dietary fiber and diverse bioactive compounds that are associated with potential health-promoting effects, including antioxidant and metabolic benefits (Cotas *et al*., 2020; Garcia-Vaquero *et al*., 2021). Indicators of utilization therefore include dietary diversity, fish consumption per capita, seaweed consumption, micronutrient intake, and nutritional status indicators.

Stability: Stability refers to the capacity of marine food systems to maintain availability, accessibility, and utilization over time despite environmental, economic, and social disturbances. Marine food systems are increasingly exposed to multiple stressors, including climate change, ocean warming, marine heatwaves, ocean acidification, extreme weather events, overfishing, habitat degradation, and pollution (IPCC, 2023; Hoegh-Guldberg *et al*., 2019; FAO, 2024).

Climate change is expected to alter fish distributions, reduce fisheries productivity in many tropical regions, and increase the vulnerability of coastal communities that depend heavily on marine resources (Allison *et al*., 2009; IPCC, 2023). Simultaneously, habitat degradation and biodiversity loss threaten the ecological foundations of marine food production (Duarte *et al*., 2020). Building stability therefore requires climate adaptation strategies, ecosystem restoration, adaptive fisheries governance, and investments in resilient food supply chains (FAO, 2024; OECD, 2023).

2.3. Marine Food Systems as Social-Ecological Systems

Marine food systems are increasingly conceptualized as social–ecological systems in which ecological dynamics and human governance structures interact through complex and adaptive feedback mechanisms, shaping system resilience and sustainability outcomes (Kittinger *et al*., 2013; Bennett *et al*., 2019). This perspective recognizes that fisheries and aquaculture cannot be understood in isolation from the ecosystems, institutions, markets, and coastal communities that collectively determine their performance, sustainability, and distributional outcomes.

The ecological subsystem comprises fish stocks, coral reefs, mangrove forests, seagrass meadows, estuaries, and other coastal and marine habitats that underpin food production and ecosystem services. These ecosystems perform critical regulating and supporting functions, including nutrient cycling, carbon

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sequestration, shoreline protection, biodiversity maintenance, and fisheries productivity, which are now widely conceptualized within blue carbon science, ecosystem-based management, and blue economy frameworks (Duarte *et al*., 2013; Hoegh-Guldberg *et al*., 2019; UNEP, 2021)

The social subsystem encompasses fishers, aquaculture producers, seaweed farmers, traders, consumers, and coastal communities whose livelihoods and well-being depend on marine resources. Social factors such as poverty, education, market access, and adaptive capacity strongly influence the resilience of marine food systems (Allison & Ellis, 2001; Béné *et al*., 2016). The governance subsystem encompasses policies, regulatory frameworks, marine spatial planning, community-based management systems, and international agreements that shape resource access and structure patterns of marine resource use. Effective governance is increasingly recognized as a central determinant of sustainability outcomes, requiring the integration of ecological integrity, social equity, and economic efficiency within adaptive and polycentric management systems (Bennett *et al*., 2019; IPCC, 2022). In fisheries and aquaculture systems, the Ecosystem Approach to Fisheries (EAF) and blue transformation agenda as key governance frameworks for ensuring sustainable resource use and resilience in marine food systems (FAO, 2022; FAO, 2024).

2.4. Blue Economy and Strong Sustainability Perspectives

The blue economy has emerged as a leading framework for promoting sustainable ocean development by emphasizing the responsible use of marine resources to generate economic growth, improve livelihoods, and maintain ecosystem health (World Bank, 2017). Fisheries, aquaculture, seaweed cultivation, marine biotechnology, and coastal tourism all represent important blue economy sectors capable of contributing to food security and poverty reduction when managed sustainably (OECD, 2023; FAO, 2024).

Complementing the blue economy concept is the principle of strong sustainability, which argues that natural capital cannot be fully replaced by human-made capital or technological innovation (Neumayer, 2013). In marine systems, natural capitals include fish stocks, coral reefs, mangroves, seagrass ecosystems, biodiversity, and ecological processes that underpin food production. Recent evidence suggests that many marine ecosystems are approaching ecological thresholds due to overexploitation, pollution, and climate change (Bennett *et al*., 2021). Restoration and conservation of marine ecosystems can simultaneously enhance biodiversity, fisheries productivity, carbon sequestration, and food security outcomes (Duarte *et al*., 2020).

2.5. Towards a Global Marine Food Security Index (GMFSI)

Existing food security assessment tools such as the Global Food Security Index (GFSI), the Food Insecurity Experience Scale (FIES), and selected Sustainable Development Goal indicators provide valuable insights into national food systems but remain largely oriented toward terrestrial agriculture (Economist Impact, 2022; FAO, 2023). Consequently, they often fail to adequately capture the contributions of fisheries, aquaculture, seaweed farming, and marine ecosystem services to food security and nutrition, particularly in coastal and island nations where aquatic foods play a central role in livelihoods and diets (Golden *et al*., 2021; FAO, 2024).

This limitation is particularly relevant for developing countries such as Indonesia, India, and Tanzania, where marine resources constitute a major source of food, employment, export earnings, and poverty alleviation. Existing indices also tend to underrepresent ecological dimensions such as fish stock sustainability, ecosystem health, and climate vulnerability, despite their critical importance for long-term food security (IPCC, 2023; Bennett *et al*., 2021). Accordingly, there is a growing need for a Global Marine Food Security Index (GMFSI) that explicitly incorporates marine-specific indicators. Such a framework should include fisheries production, aquaculture performance, seaweed production, fish consumption, aquatic protein contribution, fisheries employment, marine ecosystem health, governance effectiveness, and climate resilience indicators. By integrating these dimensions, the GMFSI would provide a more comprehensive assessment of marine food security and support evidence-based policymaking aimed at strengthening sustainable blue food systems in developing countries (FAO, 2024; Golden *et al*., 2021; Costello *et al*., 2023).

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3. Marine Food Security Status in Indonesia, India, and Tanzania

3.1. Indonesia

Marine Resource Profile: Indonesia possesses one of the world's most extensive and biologically diverse marine environments. As the largest archipelagic nation, approximately 6.4 million km² of marine territory, the country occupies a strategic position within the Coral Triangle, widely recognized as the global center of marine biodiversity (Ministry of Marine Affairs and Fisheries, 2024; FAO, 2024). Indonesian waters support exceptionally rich fisheries resources, coral reefs, mangrove forests, seagrass ecosystems, and marine habitats that underpin food production, livelihoods, and ecosystem services.

Indonesia ranks among the world's leading fish-producing nations. According to the latest national fisheries statistics, total fisheries production exceeds 24 million tonnes annually, with aquaculture contributing a larger share than capture fisheries (Ministry of Marine Affairs and Fisheries, 2024). Aquaculture has expanded rapidly over the past two decades, particularly in shrimp, milkfish, tilapia, catfish, and seaweed production, making the sector a critical contributor to national food security and economic growth (FAO, 2024). Seaweed cultivation represents one of Indonesia's most important marine industries. Indonesia is consistently ranked among the world's largest producers of tropical seaweeds, particularly *Kappaphycus alvarezii* (Aslan, *et al*., 2020; Hasriah, *et al*. 2019) and *Eucheuma denticulatum* (Aslan *et al*., 2024a, b), which serve as primary raw materials for carrageenan production (FAO, 2024). The seaweed sector supports hundreds of thousands of coastal households while contributing significantly to export earnings and rural development (Valderrama *et al*., 2015).

Contribution to Food Security: Marine resources play a central role in Indonesia's food and nutrition security. Fish remains one of the most important animal protein sources in the national diet. Per capita fish consumption has increased substantially during the last decade and now exceeds 55 kg per person annually, reflecting both growing availability and increasing public awareness of nutritional benefits (Ministry of Marine Affairs and Fisheries, 2024). The fisheries and aquaculture sectors provide direct and indirect employment for millions of Indonesians. Small-scale fisheries are particularly important in remote coastal and island communities where alternative livelihood opportunities remain limited (FAO, 2024). Beyond employment, fisheries products constitute an important source of export revenue. Indonesia is among the world's largest exporters of shrimp, tuna, seaweed products, and other seafood commodities, generating substantial foreign exchange earnings and supporting national economic development (World Bank, 2023).

Major Vulnerabilities: Despite its enormous marine resource base, Indonesia faces several challenges that threaten long-term marine food security. Climate change has emerged as a major concern through rising sea surface temperatures, ocean acidification, changing fish migration patterns, and increased frequency of extreme weather events (IPCC, 2023). Recent studies suggest that tropical fisheries may experience significant declines in productivity as ocean warming intensifies (Cheung *et al*., 2016). Coastal ecosystem degradation further threatens fisheries productivity. Indonesia has experienced substantial losses of mangroves, coral reefs, and seagrass habitats due to coastal development, destructive fishing practices, pollution, and land-use change (UNEP, 2021). These ecosystems provide essential nursery grounds and ecological functions that sustain fisheries' production.

In several regions, mining-related pollution has become an emerging threat to marine food systems. Nickel, cobalt, and other mineral extraction activities in eastern Indonesia have been associated with sedimentation, heavy metal contamination, and declining coastal water quality, raising concerns about impacts on fisheries, aquaculture, and seaweed farming systems (World Bank, 2022; UNEP, 2021). Governance challenges, including illegal, unreported, and unregulated (IUU) fishing, overlapping institutional mandates, and enforcement limitations, continue to complicate sustainable resource management (FAO, 2024).

3.2. India

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Marine Resource Profile: Marine fisheries, inland fisheries, and aquaculture in India collectively contribute to food security, employment, and economic development throughout the country. The fisheries sector has experienced remarkable growth, particularly through the expansion of aquaculture. India is currently among the world's largest aquaculture producers, with freshwater aquaculture accounting for a substantial share of total fish production (FAO, 2024). Species such as carp, shrimp, catfish, and freshwater prawns dominate production systems and contribute significantly to domestic food supplies and exports. Coastal fisheries remain equally important, particularly along the eastern and western seaboards. Marine capture fisheries support millions of fishers and provide valuable sources of protein and micronutrients for coastal populations (Government of India, 2024).

Contribution to Food Security: Fish and aquatic foods play a critical role in improving dietary quality and nutritional security in India. Although fish consumption varies considerably across regions and cultural groups, aquatic foods provide essential proteins, omega-3 fatty acids, and micronutrients for millions of households (Thilsted *et al*., 2016). The fisheries sector supports more than 28 million livelihoods through fishing, aquaculture, processing, marketing, and associated industries (FAO, 2024). Beyond its nutritional role, the sector contributes substantially to national income, rural development, and export earnings. India is among the world's largest exporters of shrimp and other seafood products, making fisheries an important component of the country's blue economy strategy (Government of India, 2024).

Major Vulnerabilities: India faces growing marine food security challenges associated with overexploitation of fish stocks, environmental degradation, and climate change. Several commercially important marine fisheries are experiencing increasing fishing pressure, raising concerns regarding long-term sustainability (FAO, 2024). Coastal pollution presents another major threat. Industrial discharge, agricultural runoff, urban wastewater, and plastic pollution have degraded water quality in many coastal regions, affecting both fisheries productivity and ecosystem health (UNEP, 2021). Climate variability further compounds these challenges. Rising sea temperatures, changing monsoon patterns, cyclones, and sea-level rise have increased uncertainty for fishers and aquaculture producers. Climate-induced shifts in species distributions may alter resource availability and affect food security among vulnerable coastal communities (IPCC, 2023; Allison *et al*., 2009).

3.3. Tanzania

Marine Resource Profile: Tanzania possesses approximately 1,424 km of coastline along the Western Indian Ocean and supports diverse marine ecosystems, including coral reefs, mangrove forests, estuaries, and seagrass meadows (United Republic of Tanzania, 2024). Although the country's fisheries sector is smaller than those of Indonesia and India, marine resources remain critically important for food security and livelihoods. Small-scale fisheries dominate marine production systems. Artisanal fishers account for the majority of marine catches and provide fish supplies for local and regional markets (FAO, 2024). These fisheries target a wide range of species, including reef fish, pelagic fish, crustaceans, and mollusks.

Tanzania is one of Africa’s leading producers of farmed seaweed. In particular, seaweed cultivation in Zanzibar has become a key livelihood activity for coastal households, especially women, contributing significantly to income generation, poverty reduction, and livelihood diversification within coastal communities (Msuya and Hurtado, 2017; Tobisson *et al*., 2021; Charisiadou *et al*., 2022). Coral reef ecosystems also represent a critical ecological asset supporting fisheries productivity, biodiversity conservation, tourism, and coastal protection. However, these ecosystems are increasingly threatened by climate change and human activities (UNEP, 2021).

Contribution to Food Security: Marine resources play a particularly important role in supporting coastal livelihoods and rural nutrition. Fish provides one of the most accessible and affordable animal protein sources for many Tanzanian households, particularly in coastal communities where poverty rates remain relatively high (FAO, 2024). Seaweed farming has emerged as a particularly important component of coastal livelihood diversification and women’s economic empowerment in Tanzania. Seaweed aquaculture significantly enhances household income stability and provides accessible employment opportunities for women in rural coastal communities, where alternative livelihood options are often limited (Msuya and

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Hurtado, 2017; Sultana *et al*., 2022 Tobisson *et al*., 2021). However, despite these benefits, the sector remains vulnerable to climate-induced stressors such as ocean warming and disease outbreaks, as well as market instability within global value chains, which collectively constrain long-term sustainability (Tobisson *et al*., 2021; FAO, 2022).

Major Vulnerabilities: Tanzania's marine food systems face significant vulnerabilities linked to climate change, infrastructure limitations, and governance capacity constraints. Coral bleaching, rising sea temperatures, and changing oceanographic conditions threaten fisheries productivity and ecosystem resilience (IPCC, 2023). Infrastructure deficiencies remain a major barrier to food security. Limited cold storage facilities, inadequate transportation networks, and high post-harvest losses reduce the efficiency of marine food supply chains and constrain market access for small-scale producers (World Bank, 2023). Governance challenges also persist. Resource monitoring, fisheries enforcement, and institutional coordination remain constrained by limited financial and technical capacity, making sustainable fisheries management more difficult to achieve (FAO, 2024).

3.4. Comparative Analysis

A comparison of Indonesia, India, and Tanzania reveals both common challenges and important differences in marine food security systems (Table 7.1). The comparative assessment reveals substantial differences in the scale, structure, and dependence of marine food systems across Indonesia, India, and Tanzania, despite their shared reliance on aquatic resources for food security, employment, and economic development (FAO, 2024; Béné *et al*., 2016). Together, these countries represent diverse marine socio-ecological systems spanning Southeast Asia, South Asia, and East Africa, providing valuable insights into the opportunities and challenges of strengthening marine food security in developing countries (Allison *et al*., 2009; Cinner *et al*., 2012).

Indonesia possesses the largest marine territory and one of the world's most productive marine economies. Located within the Coral Triangle, Indonesia hosts some of the highest levels of marine biodiversity globally and supports extensive capture fisheries, aquaculture industries, and seaweed farming systems (FAO, 2024; Ministry of Marine Affairs and Fisheries of Indonesia, 2024). Total fisheries and aquaculture production exceeds 24 million tonnes annually, making Indonesia one of the leading aquatic food producers worldwide (FAO, 2024). Furthermore, Indonesia dominates global tropical seaweed production and contributes a substantial share of the world's carrageenan-producing seaweed supply, generating employment and export earnings for coastal communities (Valderrama *et al*., 2015; FAO, 2024).

India, in contrast, possesses one of the world's largest fisheries and aquaculture sectors and supports the largest fisheries workforce among the three countries examined (Government of India, 2024; FAO, 2024). The rapid expansion of freshwater aquaculture has transformed India into one of the world's leading aquaculture producers, significantly contributing to domestic food supplies and export growth (FAO, 2024; Costello *et al*., 2023). Although average per capita fish consumption remains relatively low compared with Indonesia, fisheries and aquaculture provide livelihoods for millions of households and play a critical role in improving food and nutrition security in several coastal and inland regions (Thilsted *et al*., 2016; Golden *et al*., 2021).

Tanzania operates on a considerably smaller production scale than Indonesia and India but exhibits a relatively high dependence on marine resources among coastal populations (United Republic of Tanzania, 2024; FAO, 2024). Small-scale fisheries constitute the backbone of marine food production and livelihood systems, while seaweed farming has emerged as one of the country's most important coastal economic activities, particularly in Zanzibar, where it contributes significantly to women's employment and household income diversification (Valderrama *et al*., 2015). Despite lower production volumes, marine resources remain vital for food security and poverty reduction among vulnerable coastal communities (Béné *et al*., 2016).

A notable distinction among the three countries concerns the role and development of seaweed production. Indonesia is recognized as the world's leading producer of tropical carrageenan seaweeds, accounting for a

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substantial proportion of global output (FAO, 2024; Valderrama *et al*., 2015). Tanzania remains Africa's most important seaweed-producing nation and has established a globally recognized smallholder-based seaweed industry, although production volumes remain significantly lower than those of Indonesia (Valderrama *et al*., 2015). India possesses substantial biophysical potential for seaweed cultivation and has recently introduced policies aimed at accelerating the development of a domestic seaweed industry as part of its blue economy strategy (Government of India, 2024).

From a nutritional perspective, Indonesia records the highest fish consumption levels among the three countries, exceeding 58 kg per capita annually, reflecting both strong domestic supply and cultural acceptance of fish-based diets (Ministry of Marine Affairs and Fisheries of Indonesia, 2024). By comparison, per capita fish consumption in India and Tanzania remains below global averages, suggesting considerable opportunities to improve dietary quality and micronutrient intake through increased access to aquatic foods (Golden *et al*., 2021; Hicks *et al*., 2019). Aquatic foods are increasingly recognized as highly nutrient-dense sources of protein, essential fatty acids, vitamins, and minerals that can contribute significantly to addressing malnutrition and micronutrient deficiencies in developing countries (Golden *et al*., 2021; Thilsted *et al*., 2016). The contribution of fisheries and aquaculture to employment also differs considerably among the three countries. India supports the largest fisheries-related workforce due to its extensive inland and coastal fisheries sectors, while Indonesia's fisheries and aquaculture industries provide employment opportunities for millions of fishers, fish farmers, processors, traders, and seaweed producers (FAO, 2024; Government of India, 2024). In Tanzania, marine livelihoods remain concentrated within small-scale fisheries and seaweed farming, making coastal communities particularly sensitive to environmental and economic shocks (Allison & Ellis, 2001; Béné *et al*., 2016).

Table 7.1. Comparative Marine Food Security Indicators in Indonesia, India, and Tanzania (Latest Available Data: 2024–2025)

Indicator	Indonesia	India	Tanzania
Population (million people)	~284.4	~1,463.9	~69.4
Coastline Length (km)	~108,000	~7,516	~1,424
Exclusive Economic Zone (EEZ) (million km²)	~6.4	~2.37	~0.24
Total Fisheries & Aquaculture Production (million tonnes/year)	~24.7	~18.9	~0.73
Capture Fisheries Production (million tonnes/year)	~7.3	~5.3	~0.40
Aquaculture Production (million tonnes/year)	~17.4	~13.6	~0.33
Seaweed Production (wet weight; million tonnes/year)	~9.5–10.2	~0.05	~0.015
Per Capita Fish Consumption (kg/person/year)	~58–60	~9–10	~8–9
Employment in Fisheries & Aquaculture (million people)	~12.5	~28.0	~4.5
Contribution of Fisheries to GDP (%)	~2.6	~1.1	~1.7
Seafood Export Value (USD billion/year)	~6.5–7.0	~8.1–8.5	~0.3
Share of Population Living in Coastal Areas (%)	~55	~30	~25
Major Aquatic Food Sources	Marine fish, tuna, shrimp, seaweed	Inland fish, shrimp, marine fish	Small pelagics, reef fish, seaweed
Main Marine Food Security Vulnerabilities	Climate change, mining pollution, coastal degradation, IUU fishing	Overfishing, pollution, climate variability	Climate impacts, weak infrastructure, governance limitations

Sources: FAO (2024); Ministry of Marine Affairs and Fisheries of Indonesia (2024); Government of India (2024); United Republic of Tanzania (2024); World Bank (2023); United Nations (2024).

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Despite differences in production systems and economic scale, all three countries face a common set of marine food security challenges. Climate change is increasingly affecting marine ecosystems through ocean warming, marine heatwaves, sea-level rise, ocean acidification, and shifts in species distribution, thereby threatening fisheries productivity and food security outcomes (IPCC, 2023; Hoegh-Guldberg *et al*., 2019; Allison *et al*., 2009). These impacts are expected to be particularly severe in tropical developing countries, where adaptive capacity often remains limited (IPCC, 2023).

Marine ecosystem degradation represents another shared concern. Coastal pollution, habitat loss, mangrove degradation, coral reef decline, and unsustainable fishing practices continue to undermine the ecological foundations of marine food production (UNEP, 2021; Duarte *et al*., 2020). Indonesia faces increasing pressures from coastal industrialization and mining-related pollution, particularly in nickel-producing regions where sedimentation and heavy metal contamination have raised concerns regarding fisheries and seaweed farming sustainability (World Bank, 2022; UNEP, 2021). India faces significant challenges associated with coastal pollution, urban wastewater discharge, plastic pollution, and intensive fishing pressure (Government of India, 2024; UNEP, 2021). Tanzania's principal constraints relate to limited infrastructure, post-harvest losses, restricted market access, and institutional capacity limitations (United Republic of Tanzania, 2024; World Bank, 2023).

Governance effectiveness remains a critical determinant of marine food security outcomes across all three countries. Challenges such as illegal, unreported, and unregulated (IUU) fishing, fragmented institutional arrangements, inadequate monitoring systems, and enforcement limitations continue to affect resource sustainability and economic efficiency (FAO, 2024; OECD, 2023). Strengthening fisheries governance through ecosystem-based fisheries management, community co-management systems, marine spatial planning, and improved monitoring frameworks has therefore become an increasingly important policy priority (Ostrom, 2009; Berkes *et al*., 2003; FAO, 2024).

Taken together, these similarities and differences provide valuable opportunities for comparative policy learning. Indonesia's success in developing globally competitive seaweed value chains, India's experience in scaling aquaculture production, and Tanzania's community-based fisheries and coastal resource management initiatives offer complementary lessons for strengthening marine food security across developing countries (FAO, 2024; World Bank, 2023). A comparative perspective suggests that future policy interventions should simultaneously address ecological sustainability, nutritional outcomes, livelihood resilience, and governance effectiveness within an integrated blue food systems framework (Costello *et al*., 2023; Golden *et al*., 2021; FAO, 2024).

Table 7.2. Marine Food Security Risk Profile in Indonesia, India, and Tanzania

Dimension	Indonesia	India	Tanzania
Climate Vulnerability	High	High	Very High
Overfishing Pressure	Moderate–High	High	Moderate
Coastal Pollution Risk	High	Very High	Moderate
Seaweed Development Potential	Very High	High	High
Aquaculture Expansion Potential	Very High	Very High	Moderate
Governance Effectiveness	Moderate	Moderate	Low–Moderate
Blue Economy Readiness	High	High	Moderate
Marine Biodiversity Importance	Very High	High	High
Food Security Dependence on Aquatic Foods	High	Moderate	High
Adaptive Capacity	Moderate	Moderate–High	Low

Sources: FAO (2024); IPCC (2023); World Bank (2023); OECD (2023); Allison *et al*. (2009).

A notable distinction among the three countries is the role of seaweed production. Indonesia dominates global tropical seaweed production, contributing nearly 40% of world output, whereas Tanzania remains Africa's leading producer despite substantially lower production volumes. India has significant potential for seaweed expansion but remains at an earlier stage of industrial development relative to Indonesia (FAO,

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2024; Valderrama *et al*., 2015). From a nutritional perspective, Indonesia records the highest fish consumption levels, exceeding 58 kg per capita annually, while India and Tanzania remain below 10 kg per capita. This disparity suggests considerable opportunities to enhance dietary quality and micronutrient intake through greater utilization of aquatic foods in both India and Tanzania (Golden *et al*., 2021; Hicks *et al*., 2019).

Despite differences in scale and production systems, the three countries face several common challenges, including climate change, ecosystem degradation, fisheries overexploitation, and governance limitations (Table 7.2). These shared vulnerabilities highlight the need for integrated marine food security policies that combine ecosystem-based fisheries management, sustainable aquaculture development, climate adaptation strategies, and blue economy approaches (IPCC, 2023; FAO, 2024; OECD, 2023).

4. Major Marine Food Security Challenges

Recent studies further demonstrate that aquatic foods have the potential to play a transformative role in addressing global malnutrition and enhancing the sustainability of food systems, particularly in low- and middle-income countries where nutrient deficiencies remain widespread (Golden *et al*., 2021; Hicks *et al*., 2019). Despite these opportunities, marine food systems are increasingly challenged by climate change, overexploitation of marine resources, habitat degradation, pollution, governance weaknesses, and socioeconomic inequalities (IPCC, 2023; FAO, 2024; Costello *et al*., 2023).

4.1. Climate Change

Climate change is widely recognized as one of the most significant long-term threats to marine food security. The ocean has absorbed the majority of excess heat generated by anthropogenic greenhouse gas emissions, leading to ocean warming, marine heatwaves, ocean acidification, and sea-level rise (IPCC, 2023). These environmental changes directly affect marine productivity, species distribution, ecosystem functioning, and fisheries-dependent livelihoods (Allison *et al*., 2009; Cheung *et al*., 2016).

Ocean warming has already altered the geographic distribution of many commercially important fish species, resulting in shifts in fisheries productivity and access to marine resources (Cheung *et al*., 2016). Such changes disproportionately affect developing countries where adaptive capacity remains limited and where coastal communities rely heavily on local fish stocks for food and income (Allison *et al*., 2009). Marine heatwaves have become more frequent and intense over recent decades. These extreme events contribute to coral bleaching, mass mortality of marine organisms, and reductions in ecosystem productivity (Hoegh-Guldberg *et al*., 2019). Coral reef degradation is particularly concerning because reef ecosystems support approximately one-quarter of all marine species and contribute substantially to fisheries production and food security in tropical regions (United Nations, 2021).

Ocean acidification further threatens marine food systems by reducing calcification rates in shell-forming organisms and compromising coral reef resilience (IPCC, 2023). Sea-level rise also increases coastal erosion, flooding, saltwater intrusion, and damage to fisheries infrastructure, creating additional challenges for marine food production and distribution systems. Recent projections suggest that climate change may significantly reduce fisheries productivity in tropical developing countries by the middle of this century if adaptive management strategies are not implemented (Cheung *et al*., 2016; Costello *et al*., 2023).

Indonesia: Indonesia faces increasing climate-related risks due to its extensive coastline, dependence on marine resources, and location within the Coral Triangle. Rising sea surface temperatures have contributed to repeated coral bleaching events and changes in fish migration patterns, affecting fisheries productivity and small-scale fishing livelihoods (Hoegh-Guldberg *et al*., 2019; Ministry of Marine Affairs and Fisheries of Indonesia, 2024).

India: India's fisheries sector is increasingly affected by ocean warming, cyclones, coastal flooding, and changing fish distributions. These impacts threaten food security and economic stability for millions of fishers and aquaculture producers (Government of India, 2024; IPCC, 2023).

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Tanzania: In Tanzania, climate change has adversely affected coral reef ecosystems and seaweed farming activities, particularly in Zanzibar. Rising seawater temperatures have reduced seaweed productivity and increased vulnerability among coastal households that depend on marine resources for their livelihoods (Valderrama *et al*., 2015; United Republic of Tanzania, 2024).

4.2. Overfishing and Resource Depletion

Overfishing remains one of the most persistent drivers of marine food insecurity globally. According to FAO (2024), approximately 37.7% of assessed marine fish stocks are currently overfished, indicating a continued decline in the sustainability of global fisheries resources. Unsustainable fishing practices, excessive fishing effort, technological intensification, and weak fisheries governance have contributed to declining fish stocks in many coastal regions (Pauly & Zeller, 2016; FAO, 2024). Illegal, unreported, and unregulated (IUU) fishing further exacerbates resource depletion and undermines fisheries management efforts.

Declining fish stocks directly reduce food availability and threaten the nutritional benefits that aquatic foods provide. Hicks *et al*. (2019) demonstrated that sustainable fisheries management could substantially reduce global micronutrient deficiencies because many fish species are rich sources of bioavailable iron, zinc, calcium, vitamin A, and omega-3 fatty acids. Consequently, overfishing represents not only an ecological challenge but also a nutrition and public health concern. The economic consequences are equally significant. Reduced catches lower fisher incomes, increase seafood prices, and disproportionately affect small-scale fisheries, which are often the primary source of employment and food security in coastal communities (Béné *et al*., 2016; Allison & Ellis, 2001).

4.3. Marine Pollution and Habitat Degradation

Marine pollution has emerged as a major threat to the sustainability of aquatic food systems. Sources of pollution include plastic debris, industrial effluents, mining waste, untreated wastewater, agricultural runoff, and coastal urbanization (UNEP, 2021). Plastic pollution is particularly concerning because microplastics are increasingly detected throughout marine food webs, raising concerns regarding seafood safety and ecosystem health (UNEP, 2021). Industrial and mining-related pollution may introduce heavy metals and toxic contaminants into coastal ecosystems, negatively affecting fisheries resources and aquaculture production. Habitat degradation compounds these challenges. Coral reefs, mangroves, and seagrass meadows provide critical ecosystem services that support fisheries productivity, biodiversity conservation, carbon sequestration, and coastal protection (Duarte *et al*., 2020). The loss of these habitats undermines the ecological foundations of marine food security.

Indonesia faces increasing environmental pressures associated with coastal development and mining activities, particularly in regions experiencing rapid nickel extraction and industrial expansion. Sedimentation and heavy-metal contamination have raised concerns regarding fisheries sustainability and seaweed cultivation (World Bank, 2022). Similar challenges are observed in India through industrial discharge and urban wastewater pollution, while Tanzania continues to experience habitat degradation associated with coastal development and resource extraction (UNEP, 2021; United Republic of Tanzania, 2024).

4.4. Governance and Institutional Constraints

Effective governance is essential for maintaining sustainable marine food systems. However, many developing countries continue to face institutional weaknesses that limit their ability to manage fisheries resources effectively. Common governance challenges include fragmented institutions, inadequate enforcement capacity, insufficient scientific data, weak monitoring systems, and limited stakeholder participation (OECD, 2023; FAO, 2024). These constraints often contribute to resource depletion, regulatory non-compliance, and conflicts among resource users. The social-ecological systems framework developed by Ostrom (2009) highlights the importance of adaptive governance arrangements capable of responding to environmental change and resource scarcity. Similarly, Berkes *et al*. (2003) emphasize that community participation and co-management approaches can enhance resource stewardship and improve long-term

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sustainability outcomes. Strengthening governance is therefore fundamental to improving marine food security, particularly in countries where fisheries remain central to livelihoods and nutrition.

4.5. Socioeconomic Vulnerabilities

Marine food security challenges are closely linked to broader socioeconomic conditions. Poverty, inequality, limited access to markets, and inadequate financial services increase vulnerability among fishing and aquaculture communities (Allison & Ellis, 2001; Béné *et al*., 2016). Small-scale fisheries are particularly important in developing countries because they provide employment, income, and affordable food for millions of people (HLPE, 2014). However, many small-scale fishers remain marginalized within national economies and face barriers to accessing credit, technology, insurance, and formal markets. Gender inequality further exacerbates vulnerability. Women contribute substantially to fish processing, marketing, and seaweed farming but frequently encounter limited access to productive assets and decision-making processes (HLPE, 2014; FAO, 2024).

4.6. Post-Harvest Losses and Supply Chain Weaknesses

Post-harvest losses remain a significant but often overlooked challenge within marine food systems. In many developing countries, inadequate cold storage facilities, poor transportation infrastructure, and inefficient supply chains result in substantial losses of fish and seafood products before they reach consumers (FAO, 2024). These losses reduce food availability, decrease fisher incomes, and undermine efforts to improve nutrition security. Given that aquatic foods are among the most nutrient-dense foods available, reducing post-harvest losses could significantly improve food system efficiency and nutrition outcomes (Golden *et al*., 2021; Thilsted *et al*., 2016).

4.7. Emerging Challenges

Beyond traditional environmental and governance concerns, marine food systems face new pressures arising from urbanization, competing ocean uses, and offshore development activities. Rapid coastal urbanization increases demand for land, infrastructure, and marine resources while generating additional pollution and habitat degradation (UNEP, 2021). Simultaneously, marine space is increasingly contested by tourism, shipping, conservation initiatives, offshore aquaculture, renewable energy projects, and seabed mining operations (OECD, 2023). As highlighted by Costello *et al*. (2023), future marine food systems must balance food production objectives with biodiversity conservation, climate adaptation, and blue economy development. Achieving this balance will require integrated ocean governance, ecosystem-based management, marine spatial planning, and cross-sectoral policy coordination (FAO, 2024; World Bank, 2017).

5. Policy Solutions for Marine Food Security

Achieving marine food security in developing countries requires policy interventions that simultaneously address ecological sustainability, nutritional outcomes, economic development, and social equity. The interconnected nature of marine food systems means that solutions cannot focus solely on increasing production; rather, they must strengthen ecosystem resilience, improve governance, enhance livelihood opportunities, and ensure equitable access to nutritious aquatic foods. Recent global assessments emphasize that sustainable fisheries, responsible aquaculture, ecosystem restoration, climate adaptation, and blue economy transformation are essential components of future food security strategies (FAO, 2024; Costello *et al*., 2023; Golden *et al*., 2021). For countries such as Indonesia, India, and Tanzania, where millions of people depend directly on marine resources for food and livelihoods, integrated policy approaches are particularly important for achieving sustainable development and the Sustainable Development Goals (SDGs).

5.1. Ecosystem-Based Fisheries Management

Core Principles

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Ecosystem-Based Fisheries Management (EBFM) has emerged as a leading framework for achieving long-term sustainability in fisheries while maintaining ecosystem integrity. Unlike conventional single-species management approaches, EBFM recognizes the interconnected relationships among fish stocks, habitats, biodiversity, environmental processes, and human activities (FAO, 2024; Pikitch *et al*., 2004). The ecosystem approach incorporates ecological interactions, cumulative environmental impacts, and socioeconomic considerations into fisheries management decisions. This perspective is particularly important under conditions of climate change, where ecosystem dynamics are becoming increasingly unpredictable (IPCC, 2023).

Adaptive management constitutes another key principle of EBFM. Fisheries management systems must be capable of responding to changing environmental conditions, emerging scientific knowledge, and evolving socioeconomic circumstances (Ostrom, 2009). Adaptive approaches rely on continuous monitoring, stakeholder engagement, and policy learning. Stakeholder participation is equally critical. Small-scale fishers, coastal communities, local governments, and indigenous groups often possess valuable ecological knowledge that can complement scientific assessments and improve compliance with management measures (Berkes *et al*., 2003).

Expected Outcomes

The implementation of ecosystem-based fisheries management can generate multiple benefits, including sustainable fish stock recovery and maintenance, improved ecosystem resilience, enhanced biodiversity conservation, reduced fishing conflicts, and increased long-term food security alongside greater socioeconomic stability for coastal communities. Evidence from marine protected areas and co-management systems demonstrates that ecosystem-based approaches can simultaneously improve ecological outcomes and fisheries productivity (Berkes *et al*., 2003; FAO, 2024).

Beyond ecological restoration, ecosystem-based fisheries management (EBFM) strengthens governance systems by integrating ecological knowledge with local institutions and stakeholder participation. This participatory approach improves compliance, enhances legitimacy of management decisions, and reduces enforcement costs, particularly in data-limited and small-scale fisheries systems. Studies have shown that leadership, social capital, and incentive structures are critical determinants of successful fisheries governance, where well-designed co-management arrangements can significantly improve resource sustainability and reduce overexploitation (Gutiérrez *et al*., 2011; Pomeroy and Andrew, 2011). In this context, social-ecological systems thinking provides a foundational framework for understanding the complex interactions between ecological dynamics and human behavior in fisheries management (Berkes *et al*., 2003).

Furthermore, ecosystem-based approaches contribute to long-term climate adaptation and risk reduction by enhancing the resilience of marine ecosystems and dependent coastal livelihoods. Healthy and well-managed fisheries systems are better able to withstand external shocks such as ocean warming, acidification, and extreme weather events. By maintaining habitat integrity and functional biodiversity, EBFM supports ecosystem services that underpin food security and income generation for vulnerable coastal populations. Recent global assessments emphasize that integrating ecosystem-based principles into fisheries policy is critical for achieving sustainable ocean governance and the objectives of the Blue Transformation agenda, as well as strengthening resilience under accelerating climate change (IPCC, 2022; FAO, 2024).

5.2. Sustainable Aquaculture Development

Aquaculture has become the fastest-growing food production sector globally and now contributes more aquatic foods for direct human consumption than capture fisheries (FAO, 2024). In the context of increasing pressure on wild fish stocks, climate change, and rising food demand, sustainable aquaculture development represents a critical pathway for strengthening marine food security, improving nutrition, and supporting coastal livelihoods in developing countries (Costello *et al*., 2023; FAO, 2024; Froehlich *et al*., 2018).

Climate-Smart Aquaculture

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Climate-smart aquaculture integrates adaptation and mitigation strategies into production systems with the aim of increasing productivity while reducing environmental impacts and enhancing resilience to climate variability and extreme events (FAO, 2024; Troell *et al*., 2014). These approaches are increasingly recognized as essential for sustaining aquaculture growth under changing ocean conditions, including warming temperatures, ocean acidification, and increasing disease outbreaks (Barange *et al*., 2018).

Climate-smart practices typically include improved water quality and effluent management, selection of heat-tolerant and fast-growing species, development of disease-resistant strains, adoption of energy-efficient technologies, and the promotion of integrated and circular production systems. Collectively, these innovations enhance system resilience while reducing greenhouse gas emissions and environmental externalities associated with aquaculture intensification (Boyd *et al*., 2020; FAO, 2024).

Integrated Multi-Trophic Aquaculture (IMTA)

Integrated Multi-Trophic Aquaculture (IMTA) combines species from different trophic levels within a single production system, enabling nutrient recycling and improving ecological efficiency. In IMTA systems, waste generated by fed species becomes a resource for extractive species, thereby reducing environmental impacts and improving overall system productivity (Troell *et al*., 2009; Chopin *et al*., 2012).

For example, finfish release nutrient-rich waste that can be assimilated by seaweed, while shellfish filter suspended particles from the water column. This synergistic interaction enhances nutrient retention, reduces eutrophication risks, and improves environmental performance compared to monoculture systems. In addition, IMTA contributes to income diversification for farmers by producing multiple marketable products within the same farming area, thereby increasing economic resilience in coastal communities (Chopin *et al*., 2012; Duarte *et al*., 2021).

Sustainable Feed Systems

The long-term sustainability of aquaculture is increasingly constrained by reliance on wild fish-derived feed ingredients such as fishmeal and fish oil. Consequently, innovation in alternative feed resources has become a key research and policy priority (Naylor *et al*., 2021; Tacon and Metian, 2015). Promising alternatives include algae-based feeds, insect meals, microbial proteins, and agricultural by-products, all of which contribute to reducing pressure on marine capture fisheries. These innovations not only improve resource-use efficiency but also enhance circularity within food systems by converting low-value biomass into high-value aquaculture inputs. Moreover, the development of novel feed ingredients is essential for decoupling aquaculture growth from marine resource extraction, thereby supporting more sustainable and climate-resilient aquatic food systems (Naylor *et al*., 2021; Froehlich *et al*., 2018).

Country Opportunities

Indonesia: Indonesia possesses significant potential for sustainable expansion of marine aquaculture, particularly in seaweed farming (Sahrir, *et al* 2014; Cahyani *et al*., 2020), mariculture, shrimp production, and integrated coastal aquaculture systems. The country's extensive coastline and favorable environmental conditions support diverse aquaculture development opportunities (Ministry of Marine Affairs and Fisheries of Indonesia, 2024).

India: India has become one of the world's largest aquaculture producers, largely driven by freshwater aquaculture systems such as carp and shrimp farming, which contribute significantly to national fish production and rural livelihoods. However, the sector is increasingly shifting toward diversification to enhance resilience, productivity, and environmental sustainability. Future opportunities are strongly aligned with the expansion of coastal mariculture, integrated aquaculture systems, and seaweed cultivation under the national Blue Economy framework (Government of India, 2024; FAO, 2024). In particular, coastal mariculture development in India is being promoted as a strategy to optimize underutilized coastal resources, reduce pressure on inland freshwater systems, and enhance export-oriented seafood production. Seaweed farming is emerging as a priority subsector, supported by government initiatives aimed at scaling production, improving seed supply chains, and strengthening value-added processing industries. These developments are

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expected to contribute not only to economic growth but also to ecosystem services such as nutrient removal and carbon sequestration, thereby supporting climate mitigation goals (FAO, 2024; World Bank, 2022).

Furthermore, integrated aquaculture systems, including Integrated Multi-Trophic Aquaculture (IMTA), are gaining attention as a means to improve resource-use efficiency and reduce environmental impacts. By combining finfish, shellfish, and seaweed production, these systems promote circular nutrient flows and diversify income streams for coastal communities. Such approaches are increasingly recognized as essential for achieving sustainable intensification of aquaculture under climate change and increasing global seafood demand (Troell *et al*., 2009; Costello *et al*., 2023). Strengthening institutional support, investment in technology transfer, and capacity building will therefore be critical for realizing India's Blue Economy potential in a sustainable and inclusive manner (World Bank, 2022).

Tanzania: Tanzania's aquaculture sector remains relatively underdeveloped but possesses substantial growth potential. Expansion of seaweed farming, milkfish culture, shellfish production, and community-based aquaculture could strengthen food security and rural livelihoods (United Republic of Tanzania, 2024; FAO, 2024). Seaweed farming, particularly in Zanzibar, already represents one of the most important coastal livelihood activities, providing income opportunities for smallholder farmers—especially women—and contributing to household economic stability in coastal communities (Msuya and Hurtado, 2017; Tobisson *et al*., 2021).

Despite this potential, the sector continues to face structural constraints including limited access to quality seed stock, weak value chains, inadequate processing infrastructure, and vulnerability to climate-related stressors such as rising sea surface temperatures and disease outbreaks in seaweed farms. These challenges constrain productivity and limit the scalability of aquaculture development. Strengthening institutional support, improving extension services, and enhancing investment in coastal aquaculture infrastructure are therefore essential to unlocking Tanzania's blue economy potential and ensuring inclusive growth (World Bank, 2022; FAO, 2024).

In addition, integrating ecosystem-based and climate-smart aquaculture approaches offers a pathway to improve sustainability and resilience. Practices such as Integrated Multi-Trophic Aquaculture (IMTA), improved farm zoning, and diversification into resilient species such as seaweed and bivalves can reduce environmental pressures while enhancing productivity. Such approaches also contribute to nutrient cycling, coastal ecosystem restoration, and climate adaptation in vulnerable marine environments (Troell *et al*., 2009; Barange *et al*., 2018). Aligning national aquaculture development strategies with global blue economy frameworks will therefore be critical for ensuring long-term sustainability and maximizing socio-economic benefits for coastal populations in Tanzania (FAO, 2024; IPCC, 2022).

5.3. Seaweed-Based Marine Food Security Strategy

Among emerging blue food solutions, seaweed represents one of the most promising resources for addressing food security, nutrition, environmental sustainability, and coastal development simultaneously. Recent studies have identified seaweed as a strategic component of future blue food systems capable of addressing micronutrient deficiencies and enhancing dietary diversity (Golden *et al*., 2021).

Environmental Benefits

Seaweed cultivation offers multiple environmental advantages, positioning it as one of the most sustainable forms of aquaculture within the emerging blue economy. Unlike terrestrial crops or intensive fed aquaculture systems, seaweed farming requires no freshwater irrigation, no synthetic fertilizers, and no external feed inputs, thereby substantially reducing pressure on land, freshwater, and terrestrial nutrient cycles. In addition, recent global assessments highlight that seaweed aquaculture has a comparatively low life-cycle carbon footprint and may contribute to climate change mitigation through avoided emissions and ecosystem-based production efficiencies, reinforcing its role in low-carbon food system transitions (Aslan *et al*., 2020c; Froehlich *et al*., 2019; Duarte *et al*., 2021; Costello *et al*., 2023; Duarte *et al*., 2017).

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Beyond resource-use efficiency, seaweed farming provides critical ecosystem services, particularly through nutrient bio extraction and participation in coastal biogeochemical cycling. Macroalgae assimilates dissolved inorganic carbon and excess nutrients such as nitrogen and phosphorus during growth, thereby contributing to carbon flux regulation and coastal water quality improvement. This capacity makes seaweed cultivation a promising nature-based solution for mitigating eutrophication in nutrient-enriched coastal zones, especially in regions affected by agricultural runoff and aquaculture effluents. Recent syntheses further emphasize the role of seaweed systems in supporting blue carbon pathways, although the permanence of carbon sequestration remains context-dependent and requires careful ecological accounting (Krause-Jensen *et al*., 2023; Duarte *et al*., 2017; Hurd *et al*., 2020).

Furthermore, integrated seaweed farming systems enhance ecosystem resilience by promoting habitat complexity and supporting marine biodiversity. Seaweed farms can function as artificial reef-like structures, offering refuge, nursery habitat, and feeding grounds for diverse marine organisms, thereby increasing local ecological heterogeneity. When integrated with finfish or shellfish culture under systems such as Integrated Multi-Trophic Aquaculture (IMTA), seaweed production contributes to circular nutrient flows and improved environmental performance of aquaculture systems. These multifunctional benefits position seaweed aquacultures not only as a food production strategy but also as a scalable nature-based solution aligned with global sustainability agendas, including climate mitigation, ocean health restoration, and sustainable food system transformation (Troell *et al*., 2023; FAO, 2024; Hasselström *et al*., 2021).

Economic Benefits

Seaweed production is vital for coastal livelihoods in Indonesia and Tanzania, contributing to income diversification, employment, export earnings, and value-added industries such as carrageenan and food products. As one of the fastest-growing marine food sectors, it is increasingly recognized as a key component of blue economy strategies due to its scalability and low environmental footprint (FAO, 2024; World Bank, 2022; Duarte *et al*., 2017). It also promotes social inclusion, particularly women's participation in farming, post-harvest processing, and marketing, thereby improving household income stability and welfare (Msuya and Hurtado, 2017; Tobisson *et al*., 2021; Troell *et al*., 2023). Expanding value chains further supports rural industrialization and export growth, although improvements in infrastructure, seed systems, and market access are required to enable smallholders to benefit fully (Hurd *et al*., 2020).

Policy Opportunities

Governments can promote seaweed as a strategic commodity for food security through its integration into school feeding programs, public nutrition interventions, hospital and military food procurement systems, social protection schemes, and broader national food diversification strategies. One illustrative example of government intervention in Indonesia as a strategic approach to food security is the incorporation of aquatic foods into national school feeding programs. Indonesia is currently intensifying efforts to improve population nutrition through the Free Nutritious Meals Program (*Makan Bergizi Gratis*/MBG). Launched in 2025, MBG is projected to become the largest and most financially significant social policy intervention in the country's history by 2026. The program is expected to reach approximately 82.9 million beneficiaries, the majority of whom are school-aged children, including around 48 million students, alongside toddlers, pregnant women, and breastfeeding mothers. This scale places MBG among the largest publicly funded school feeding and nutrition programs globally. Evidence from OECD countries further underscores the role of school-based nutrition programs in improving educational outcomes and reducing inequalities in human development trajectories (OECD, 2023). Within this context, MBG functions as a strategic policy instrument for addressing malnutrition, improving dietary quality, and enhancing long-term national productivity.

Within the broader development framework, marine food security and the MBG initiative are increasingly aligned under the emerging paradigm of blue food system transformation. Aquatic foods are now widely recognized as integral components of sustainable nutrition and global food security strategies. Marine food systems offer a continuous supply of nutrient-rich foods, particularly fish and seaweed, thereby supporting dietary diversification and strengthening the resilience of national nutrition programs (FAO, 2022; FAO,

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2024). Indonesia's position as one of the world's leading producers of farmed seaweed further enhances its potential as a scalable and cost-efficient food source for national school feeding programs.

The rationale for integrating seaweed into the MBG program is multifaceted. First, it contributes directly to improved child nutrition by providing essential micronutrients required for cognitive development, immune function, and physical growth. Second, its low input requirements and high availability make it well suited for large-scale implementation within Indonesia's extensive food distribution and education systems. Third, its inclusion in MBG is expected to generate positive spillover effects for coastal economies through increased demand for raw materials and the expansion of value-added processing activities within local supply chains. Fourth, sustained institutional demand from public nutrition programs can enhance market stability for seaweed producers and strengthen livelihood security in coastal communities. Fifth, the incorporation of seaweed-based meals may also foster early dietary awareness among school-aged populations regarding the nutritional benefits of aquatic foods. Empirical evidence from Aslan *et al*. (2025) indicates a very high willingness (approximately 95%) among students in Kendari, Southeast Sulawesi, Indonesia, to continue consuming seaweed following school-based nutritional interventions. In summary, the integration of seaweed into the MBG program should not be interpreted merely as a dietary supplementation strategy. Rather, it represents a structural policy innovation that advances a more sustainable, resilient, and inclusive national food system grounded in marine food security, human capital development, and the blue economy framework.

5.4. Strengthening Small-Scale Fisheries

Small-scale fisheries account for a substantial share of global fish production and support the livelihoods of hundreds of millions of people (HLPE, 2014). The FAO Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries (SSF Guidelines) provide a comprehensive framework for enhancing the social, economic, and environmental sustainability of small-scale fisheries (FAO, 2015).

Priority Areas

Securing Tenure Rights: Secure and well-defined resource access rights contribute to improved stewardship of marine resources and help reduce conflicts among fishing communities. Strengthening tenure systems also enhances accountability and encourages more sustainable resource use practices.

Financial Inclusion: Enhanced access to financial services including credit, savings facilities, insurance schemes, and digital financial platforms plays a critical role in strengthening the resilience of fishing households. Such financial instruments enable greater investment capacity, income smoothing, and risk management in the face of economic and environmental shocks.

Capacity Building: Capacity development programs should prioritize training in sustainable fishing practices, small-scale fisheries management, business and financial literacy, digital skills, and climate adaptation strategies. Investments in human capital of this nature are essential for improving productivity, strengthening adaptive capacity, and enhancing overall livelihood outcomes in coastal communities.

5.5. Climate Adaptation and Resilience

Climate adaptation has become a central pillar of marine food security policy, particularly in the context of increasing climate variability and extreme weather events.

Early Warning Systems: Strengthened early warning systems, including improved meteorological forecasting and ocean monitoring, are essential for reducing disaster risk and supporting informed decision-making among fishers and aquaculture producers (IPCC, 2023). These systems enhance preparedness and reduce operational and safety risks in marine-based livelihoods.

Climate-Resilient Aquaculture: Climate-resilient aquaculture strategies include diversification of species, selective breeding for stress tolerance, improved farm design, and integrated risk management planning. These measures collectively enhance system stability and reduce vulnerability to climate-induced shocks.

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Risk Insurance: Index-based and conventional insurance mechanisms provide an important safety net for fishers and aquaculture farmers by mitigating income losses resulting from climate-related disasters. Such instruments contribute to long-term resilience by stabilizing household income and supporting post-disaster recovery.

5.6. Combating Illegal, Unreported and Unregulated (IUU) Fishing

Illegal, unreported and unregulated (IUU) fishing remains a major threat to fisheries sustainability, undermining governance systems, depleting fish stocks, and reducing the economic and social benefits derived from marine resources (FAO, 2024). Addressing IUU fishing is therefore a critical component of effective marine resource management and food security policy.

Key Strategies

Vessel Monitoring Systems (VMS): The deployment of satellite-based vessel monitoring systems enhances real-time tracking of fishing activities, thereby strengthening compliance, surveillance, and enforcement capacity across fisheries jurisdictions.

Port State Measures: The FAO Port State Measures Agreement (PSMA) represents the first legally binding international instrument specifically designed to combat IUU fishing. It provides a globally recognized framework to prevent illegally harvested fish from entering domestic and international markets (FAO, 2016).

Traceability Systems: Digital traceability mechanisms across seafood value chains improve transparency, enable product verification, and strengthen accountability from harvest to final market destination. These systems are increasingly important for ensuring legal compliance and supporting sustainable seafood certification and trade governance.

5.7. Digital Transformation of Fisheries

Emerging digital technologies are creating significant opportunities to enhance marine resource management and improve the efficiency, transparency, and resilience of food systems.

Artificial Intelligence (AI): Artificial intelligence can support a wide range of fisheries and aquaculture applications, including fish stock assessment, catch and production forecasting, disease surveillance, and supply chain optimization. These capabilities improve decision-making and contribute to more efficient and sustainable resource use.

Remote Sensing: Satellite-based remote sensing technologies enable continuous monitoring of fishing activities, habitat conditions, ocean productivity, and climate-related changes. Such data are increasingly important for evidence-based fisheries management and ecosystem-based planning.

Mobile Applications: Mobile technologies play a critical role in improving access to essential services for coastal communities, including weather forecasts, market price information, digital financial transactions, and extension and advisory services. These tools enhance operational efficiency and support livelihood resilience.

Blockchain Traceability: Blockchain-based systems strengthen seafood traceability by providing secure, tamper-resistant records across supply chains. This improves transparency, reduces the risk of fraud, and enhances consumer confidence in seafood products (World Bank, 2023).

5.8. Blue Economy Transformation

Recent global policy and scientific assessments increasingly emphasize the role of aquatic food systems in achieving the Sustainable Development Goals (SDGs), particularly those related to zero hunger, climate action, and life below water. The Food and Agriculture Organization highlights that “Blue Transformation” strategies are required to expand sustainable aquaculture, improve fisheries governance, and enhance the contribution of aquatic foods to healthy diets and equitable development outcomes (FAO, 2024). Similarly, the World Bank and OECD underline that blue economy investments can generate substantial co-benefits

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when aligned with inclusive governance, ecosystem restoration, and value chain development in coastal regions (World Bank, 2022; OECD, 2023).

Within this transformation agenda, seaweed and other low-trophic aquaculture systems are increasingly recognized as strategic entry points for sustainable ocean-based food production. These systems require minimal external inputs, contribute to nutrient recycling, and offer scalable opportunities for climate-smart food production. Evidence further suggests that integrating aquatic foods into national food systems enhances both nutritional security and environmental sustainability, particularly in vulnerable coastal economies exposed to climate change impacts (FAO, 2022; Duarte *et al*., 2017). Consequently, strengthening marine food systems through a blue economy lens represents a critical pathway for aligning food security objectives with long-term ecological sustainability and economic resilience.

6. A Proposed Global Marine Food Security Index (GMFSI)

6.1. Rationale: Why a New Index is Needed

Food security has traditionally been assessed through indicators that emphasize terrestrial agriculture, household income, food affordability, and macroeconomic conditions. Widely used frameworks, including the Global Food Security Index (GFSI), the Food Insecurity Experience Scale (FIES), and national food security assessments, have significantly improved understanding of food access and availability. Nevertheless, these frameworks rarely distinguish the specific contributions of marine and aquatic food systems to food security outcomes, despite the growing recognition that aquatic foods are essential components of sustainable food systems (FAO, 2024; Golden *et al*., 2021).

Marine foods including fish, shellfish, seaweed, and other aquatic organisms—provide critical nutrients for billions of people worldwide. According to the Food and Agriculture Organization, global fisheries and aquaculture production reached 223.2 million tonnes in 2022, with aquatic foods supplying approximately 15% of animal protein consumed globally and substantially higher proportions in many coastal and island nations (FAO, 2024). In developing countries, marine resources support livelihoods, employment, export earnings, and local food systems, making them indispensable for both economic and nutritional security (Garcia and Rosenberg, 2010).

Despite this importance, current food security indices tend to treat fish and aquatic foods as minor components within broader food categories. Consequently, countries with highly productive marine sectors may receive food security assessments that inadequately reflect the contribution of fisheries, aquaculture, and seaweed farming to national well-being. Similarly, countries experiencing declines in fish stocks, coastal ecosystem degradation, or climate-induced disruptions to marine food systems may not be adequately identified as facing emerging food security risks.

Recent studies have highlighted the growing importance of aquatic foods in addressing global challenges associated with malnutrition, micronutrient deficiencies, and sustainable food production (Golden *et al*., 2016; Golden *et al*., 2021). At the same time, climate change, overfishing, habitat degradation, and illegal, unreported, and unregulated (IUU) fishing continue to threaten the capacity of marine ecosystems to provide food and livelihoods (Allison *et al*., 2009; Pauly and Zeller, 2016). These developments underscore the need for a dedicated measurement framework capable of capturing the multiple dimensions of marine food security. The proposed Global Marine Food Security Index (GMFSI) seeks to address this gap by providing a policy-oriented tool that evaluates the capacity of countries to produce, access, utilize, and sustain marine food resources. The index is intended not only to facilitate international comparisons but also to support evidence-based policymaking within the broader context of blue economy development, climate adaptation, and sustainable ocean governance.

6.2. GMFSI Framework

The GMFSI is conceptualized as a multidimensional composite index that integrates four interrelated dimensions of marine food security: Availability, Accessibility, Utilization, and Sustainability and Resilience. These dimensions build upon the classical food security framework developed by FAO while

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incorporating marine-specific considerations associated with ecosystem sustainability and climate vulnerability (HLPE, 2014; FAO, 2024).

Dimension 1: Availability: Availability refers to the capacity of marine systems to supply sufficient quantities of food to meet current and future demand. This dimension reflects the productive potential of fisheries, aquaculture, and seaweed farming. Proposed indicators include Fisheries production (kg per capita), Aquaculture production (kg per capita) and Seaweed production (kg per capita). Capture fisheries remain a major source of food and income for coastal populations worldwide, while aquaculture has become the fastest-growing food production sector globally (FAO, 2024). Seaweed production is increasingly recognized as an important contributor to food security, industrial development, and environmental sustainability, particularly in Asia and emerging cultivation regions in Africa and Latin America (Cai *et al*., 2021).

Dimension 2: Accessibility: Accessibility refers to the ability of individuals and communities to obtain marine foods through economic, physical, and social means. Proposed indicators include Fish affordability index, Employment in fisheries, aquaculture, and seaweed sectors and Market accessibility and infrastructure. Even when marine foods are abundant, barriers related to income, transportation, infrastructure, and market integration may limit access among vulnerable populations. Small-scale fisheries alone support the livelihoods of approximately 600 million people globally and play a central role in food access for many coastal communities (HLPE, 2014; FAO, 2024).

Dimension 3: Utilization: Utilization reflects the nutritional contribution of marine foods and the extent to which populations benefit from their consumption. Proposed indicators include Fish consumption per capita and Nutritional adequacy derived from marine foods. Fish and other aquatic foods provide highly bioavailable nutrients and other micronutrients necessary for human health (Golden *et al*., 2016; Golden *et al*., 2021). Consequently, this dimension captures the nutritional outcomes associated with marine food systems rather than merely measuring production levels.

Dimension 4: Sustainability and Resilience: Sustainability and resilience assess the long-term capacity of marine ecosystems and food systems to continue providing food under changing environmental and socio-economic conditions. Proposed indicators include Fish stock status, Ecosystem health. and Climate resilience. Evidence suggests that many fisheries are under increasing pressure from overexploitation, climate change, and habitat degradation (Pauly and Zeller, 2016). Furthermore, climate-driven changes in ocean temperature, productivity, and species distribution may significantly alter fisheries' yields and national food security outcomes, particularly in tropical developing countries (Allison *et al*., 2009). This dimension therefore ensures that countries are not rewarded solely with high production levels but also with maintaining the ecological foundations necessary for future food security.

6.3. Seaweed Security Sub-Index

A distinctive feature of the proposed GMFSI is the inclusion of a Seaweed Security Sub-Index (SSI). Although seaweed is increasingly recognized as a strategic component of future food systems, it remains largely absent from existing food security assessments.

The **Seaweed Security Sub-Index** is designed to capture the multidimensional role of seaweed within national food systems by integrating production, nutritional, socio-economic, and environmental dimensions into a single analytical framework. This sub-index recognizes seaweed not only as an aquaculture commodity but also as a strategic resource contributing to food security, livelihood resilience, and ecosystem sustainability. The sub-index consists of four core components:

Production assesses national seaweed production capacity, productivity levels, and temporal growth trends, thereby reflecting the sector's ability to supply sufficient raw material to meet domestic and export demand.

Consumption evaluates the extent to which seaweed contributes to national dietary intake, food diversification, and broader nutritional security outcomes, particularly in relation to micronutrient availability and healthy diet transitions.

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Livelihoods capture the socio-economic importance of seaweed farming through indicators such as employment generation, household income contribution, gender inclusion, and poverty reduction effects in coastal communities.

Environmental Performance measures the ecological functions associated with seaweed cultivation, including nutrient bio extraction, carbon sequestration potential, habitat enhancement, and the reduction of greenhouse gas emissions relative to conventional food production systems.

Seaweed farming offers a unique opportunity to align food production with environmental sustainability because it does not require freshwater, arable land, or synthetic fertilizers, while simultaneously contributing to nutrient cycling, coastal water quality improvement, and climate change mitigation (Duarte *et al*., 2017; Cai *et al*., 2021). In addition, seaweed systems are increasingly recognized as nature-based solutions that generate multiple ecosystem services, particularly in nutrient-enriched and climate-vulnerable coastal zones.

Consequently, the inclusion of a dedicated Seaweed Security Sub-Index significantly strengthens the comprehensiveness of the Global Marine Food Security Index (GMFSI). It ensures that emerging blue food systems are adequately represented within food security assessment frameworks and reflects the growing scientific and policy consensus on the strategic role of macroalgae in sustainable ocean-based food systems (FAO, 2024; World Bank, 2022).

6.4. Application to Indonesia, India, and Tanzania

Comparative Assessment

Indonesia, India, and Tanzania provide valuable case studies for testing the applicability of the GMFSI because all three countries possess extensive coastlines, substantial fisheries resources, and growing aquaculture sectors, yet differ considerably in socio-economic conditions, governance capacity, and marine food system development.

Indonesia is one of the world's leading producers of marine fish and tropical seaweeds. The country's vast archipelagic geography, large coastal population, and significant aquaculture industry suggest strong performance in the availability dimension. However, regional disparities, environmental degradation, and governance challenges may affect sustainability outcomes.

India possesses one of the world's largest fisheries sectors and a rapidly expanding aquaculture industry. Fisheries contribute significantly to employment and export earnings, although nutritional benefits from marine foods vary considerably across regions due to differences in dietary preferences, income, and infrastructure.

Tanzania represents a contrasting context where fisheries play a critical role in local livelihoods and food security, particularly in coastal communities. However, lower production levels, limited infrastructure, and climate vulnerability may constrain accessibility and resilience compared with larger Asian producers (Allison *et al*., 2009). The GMFSI framework enables systematic comparison among these countries while highlighting the specific strengths and weaknesses of their marine food systems.

Policy Relevance

The proposed GMFSI has several practical applications for policymakers, development agencies, and international organizations.

First, it provides a standardized framework for monitoring marine food security performance over time. Second, it enables governments to identify priority intervention areas, such as improving fish affordability, strengthening fisheries governance, expanding sustainable aquaculture, or enhancing climate resilience. Third, it supports the integration of marine food systems into broader food security and blue economy strategies. For countries such as Indonesia, India, and Tanzania, the GMFSI can serve as a decision-support tool for balancing economic development, nutritional improvement, and environmental sustainability. By explicitly recognizing fisheries, aquaculture, and seaweed as pillars of food security, the index offers a more

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comprehensive perspective on the role of oceans in achieving sustainable development goals and ensuring long-term food and nutrition security.

7. Future Outlook and Policy Recommendations

7.1. Marine Food Systems Toward 2050

Marine food systems are expected to play an increasingly central role in global food security as the world moves toward 2050. The convergence of population growth, climate change, and rising demand for nutrient-dense "blue foods" is reshaping the future of fisheries, aquaculture, and coastal livelihoods. At the same time, climate change is altering ocean temperature, productivity, and species distribution, with direct implications for fisheries yields and coastal food security. Evidence shows that tropical regions are likely to experience declining fisheries productivity, while higher-latitude regions may see short-term gains, creating new geographic inequalities in marine food availability (Allison *et al*., 2009). These changes are expected to intensify pressure on already vulnerable coastal communities that depend heavily on marine resources.

Another major trend is the rapid expansion of "blue foods," including fish, shellfish, and seaweed, as part of global sustainable food system strategies. Aquatic foods are increasingly positioned as a critical component of climate-resilient diets due to their relatively low environmental footprint compared to terrestrial livestock systems (FAO, 2024; Golden *et al*., 2021). Within this shift, seaweed has emerged as a strategic commodity due to its scalability, minimal resource requirements, and potential contributions to nutrition, livelihoods, and ecosystem services. Together, these trends suggest that marine food systems will not only expand in economic importance but also become central to global strategies for addressing hunger, malnutrition, and climate adaptation.

7.2. Strategic Policy Recommendations

The future resilience of marine food systems depends on targeted, context-specific policy interventions that strengthen production, governance, and sustainability while ensuring equitable access to marine foods.

Indonesia

Indonesia, as one of the world's largest archipelagic states and a leading producer of tropical seaweed, possesses substantial potential to further strengthen its marine food systems. Key policy priorities include the following:

Expansion of seaweed-based food systems: Seaweed cultivation should be repositioned beyond its traditional role as an export-oriented commodity and increasingly integrated into domestic food and nutrition strategies. This shift is consistent with growing evidence on the nutritional value and environmental sustainability of aquatic plant-based foods, particularly their role in low-input, climate-resilient food systems (Cai *et al*., 2021).

Strengthening fisheries governance: Enhancing monitoring, compliance, and enforcement mechanisms, alongside the expansion of co-management arrangements, is essential to address overexploitation and ensure the long-term sustainability of capturing fisheries resources (FAO, 2024).

Addressing coastal mining impacts: Mitigating pollution from coastal and marine extractive activities is critical to safeguarding ecosystem integrity, maintaining aquaculture productivity, and ensuring seafood safety in coastal food systems.

India

India's marine food system is characterized by a large capture fisheries sector and a rapidly expanding aquaculture industry, yet it continues to face challenges related to environmental sustainability and uneven nutritional outcomes.

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Sustainable aquaculture expansion: Future aquaculture growth should prioritize environmentally responsible production systems, including reduced dependence on fish-based feeds, improved biosecurity and disease management, and the application of ecosystem-based spatial planning approaches (FAO, 2024).

Improving fisheries management: Strengthening fisheries governance through improved stock assessment systems, effective regulatory enforcement, and community-based management approaches is essential for sustaining productivity and enhancing the resilience of marine resources (Garcia and Rosenberg, 2010).

Tanzania

Tanzania represents a coastal economy in which small-scale fisheries and seaweed farming play a central role in livelihoods and food security, yet both sectors remain highly vulnerable to environmental pressures and institutional constraints.

Strengthening small-scale fisheries: Policy interventions should prioritize inclusive governance frameworks that support artisanal fishers, improve access to markets, and enhance value addition within local fisheries value chains, in line with sustainable small-scale fisheries guidelines (HLPE, 2014).

Expanding seaweed value chains: Seaweed farming along coastal communities should be scaled through targeted investment in processing capacity, product diversification, and market integration, given its low environmental footprint and strong potential for livelihood enhancement and women's economic empowerment (Duarte *et al*., 2017).

Cross-Country Priorities: Despite differences in economic structure and marine resource endowments, Indonesia, India, and Tanzania share a set of increasingly convergent policy priorities. These commonalities reflect persistent challenges related to fisheries sustainability, food security, and the resilience of coastal livelihoods, as well as the expanding relevance of the blue economy framework in shaping marine policy agendas.

First, Ecosystem-based fisheries management (EBFM): Fisheries governance is progressively shifting away from narrow, single-species management approaches towards ecosystem-based frameworks that explicitly consider ecological interactions, habitat integrity, and the long-term sustainability of marine systems (FAO, 2024).

Second, Climate adaptation in marine food systems: Strengthening climate adaptation capacity is increasingly urgent in response to ocean warming, changes in species distribution, and heightened climate variability, all of which have direct implications for fisheries productivity and food security in coastal regions (Allison *et al*., 2009).

Third, Sustainable aquaculture development: Aquaculture expansion needs to be carefully aligned with environmental limits, social inclusion objectives, and ecosystem carrying capacity in order to ensure long-term sustainability and avoid the accumulation of ecological and socio-economic risks (FAO, 2024).

Fourth, Mainstreaming seaweed in food systems: Seaweed is increasingly recognized as a strategic resource that can be integrated into national food security policies, given its combined contributions to nutrition, livelihood diversification, and climate change mitigation (Cai *et al*., 2021).

Fifth, Blue economy development: Blue economy strategies require a careful balance between economic expansion and ecological sustainability, ensuring that marine resource use supports inclusive growth while maintaining ecosystem integrity (World Bank, 2017).

Sixth, Digital transformation of fisheries: The uptake of digital technologies including vessel monitoring systems, satellite-based surveillance, and data-driven enforcement tools has become central to efforts to improve fisheries governance and combat illegal, unreported, and unregulated (IUU) fishing (Global Fishing Watch, 2025).

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Seventh, Adoption of the Global Marine Food Security Index (GMFSI): The GMFSI provides a structured analytical framework for assessing national marine food security performance, identifying key vulnerabilities, and supporting evidence-based policy interventions across diverse national contexts.

8. Conclusions

Marine food systems have become an increasingly important component of global food and nutrition security, particularly in coastal and island nations where fisheries, aquaculture, and associated marine-based livelihoods remain central to food supply and rural economies. A growing body of evidence shows that aquatic foods make a substantial contribution to dietary protein and essential micronutrient intake, while also sustaining employment and income for millions of people, especially in developing regions. As a result, marine resources are now widely recognized as integral to broader sustainable development and food system transformation agendas, rather than peripheral to food security discourse.

Comparative analysis of Indonesia, India, and Tanzania reveals a set of shared structural challenges despite differences in economic development levels and marine resource endowments. These include ecological pressures such as overfishing and habitat degradation, socioeconomic constraints related to unequal market access and value distribution, and institutional limitations in monitoring, enforcement, and fisheries governance. Climate change further intensifies these pressures through ocean warming, shifting fish stocks, and increased variability in marine productivity, thereby heightening uncertainty for coastal livelihoods. Collectively, these dynamics underscore a common need to strengthen the resilience and adaptive capacity of marine food systems across all three countries.

Addressing these challenges requires more integrated and system-oriented policy responses. Traditional sector-based management approaches are increasingly inadequate in addressing the interlinked nature of food security, ecosystem integrity, and coastal development. Instead, ecosystem-based fisheries management, improved aquaculture governance, and strengthened climate adaptation strategies must be embedded within broader blue economy frameworks to ensure long-term sustainability and resilience.

Within this context, seaweed emerges as a strategically important yet still underutilized resource. Beyond its established commercial uses, seaweed has significant potential to enhance food and nutrition security, diversify coastal livelihoods, and contribute to climate change mitigation through carbon sequestration and nutrient cycling. Its low-input production system and wide ecological benefits position as a key component of future blue food system strategies, although realizing this potential will require stronger investment in value chain development, applied research, and policy integration.

Finally, the proposed Global Marine Food Security Index (GMFSI) provides a novel analytical framework for assessing marine food security in a more integrated manner. By combining dimensions of availability, access, utilization, and environmental sustainability, the index moves beyond fragmented indicators and offers a unified basis for policy analysis. The inclusion of seaweed as a distinct component further reflects the evolving architecture of global blue food systems and supports more targeted, evidence-based policymaking, particularly in the Global South where marine food systems are both highly vulnerable and critically important.

References

Allison, E.H. and Ellis, F. (2001) 'The livelihoods approach and management of small-scale fisheries', *Marine Policy*, 25(5), pp. 377–388. https://doi.org/10.1016/S0308-597X(01)00023-9

Allison, E.H., Perry, A.L., Badjeck, M.-C., Adger, W.N., Brown, K., Conway, D., Halls, A.S., Pilling, G.M., Reynolds, J.D., Andrew, N.L. and Dulvy, N.K. (2009) 'Vulnerability of national economies to the impacts of climate change on fisheries', *Fish and Fisheries*, 10(2), pp. 173–196. https://doi.org/10.1111/j.1467-2979.2008.00310.x

Aslan, L.O.M., Supendy, R., Taridala, S.A.A., Hafid, H., Sifatu, W.O., Sailan, Z. and Niampe, L. (2018) 'Income of seaweed farming households: A case study from Lemo of Indonesia', *IOP Conference Series: Earth and Environmental Science*, 175, 012221. https://doi.org/10.1088/1755-1315/175/1/012221

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Aslan, L. O. M., Tamrin, Baka, W.K., Taridala, S.A.A., Sabilu, Y. and Rianse, U. (2025) *Assessment of the Nutritional Composition of Seaweed for Inclusion in the Free Nutritious Meal (MBG) Program*. Final Research Report. Halu Oleo University, Kendari, Indonesia. (In Indonesian).

Aslan, L.O.M., Wianti, N.I., Taridala, S.A.A., Rahim, M., Ruslaini and Sifatu, W.O. (2022) 'The debt trap of seaweed farmers: a case study from Bajo Community in Bungin Permai, Indonesia', *IOP Conference Series: Earth and Environmental Science*, 1033, 012056. https://doi.org/10.1088/1755-1315/1033/1/012056

Aslan, L.O.M., Cahyani, H., Hardianti, H., Kurnia, D.P., Febriani, A., Prity, N.A., Ariskanti, H., Disnawati and Iba, W. (2020c) 'Field cultivation of *Kappaphycus alvarezii* (Doty) Doty ex Silva…', *IOP Conference Series: Earth and Environmental Science*, 473, 012007. https://doi.org/10.1088/1755-1315/473/1/012007

Aslan, L.O.M., La Embi, A., Hasriah, R., Ansa, A., Iba, W., Patadjai, A.B., Rahim, M. and Armin (2020) 'Grafting of the seaweed *Kappaphycus alvarezii*…', *Aquaculture Research*. https://doi.org/10.1111/are.14972

Aslan, L.O.M., Rahim, M., Taridala, S.A.A., Munier, M.T., Sifatu, W.O. and Sangkia, F.D. (2024) 'Seaweed farming households and their livelihood strategies in North Buton, Indonesia', *IOP Conference Series: Earth and Environmental Science*, 1413, 012132. https://doi.org/10.1088/1755-1315/1413/1/012132

Aslan, L.O.M., Yuniar, S., Balubi, M., Ruslaini, Sabilu, K., Aslin, L.O., Muskita, W.H. and Boer, D. (2024a) 'Growth and quality of seaweeds (*Kappaphycus alvarezii* and *Eucheuma denticulatum*)…', *IOP Conference Series: Earth and Environmental Science*, 1413, 012136. https://doi.org/10.1088/1755-1315/1413/1/012136

Badan Informasi Geospasial (BIG) (2024) *Gazeter Republik Indonesia*. Available at: https://www.big.go.id (Accessed: 2 June 2026).

Barange, M., Bahri, T., Beveridge, M. C., Cochrane, K. L., Funge-Smith, S., & Poulain, F. (2018). Impacts of climate change on fisheries and aquaculture. *United Nations' Food and Agriculture Organization*, *12*(4), 628-635.https://www.researchgate.net/profile/Manuel-Barange/publication/325871167_Impacts_of_Climate_Change_on_Fisheries_and_Aquaculture_Synthesis_of_Current_Knowledge_Adaptation_and_Mitigation_Options/links/5b5f1e48aca272a2d6754247/Impacts-of-Climate-Change-on-Fisheries-and-Aquaculture-Synthesis-of-Current-Knowledge-Adaptation-and-Mitigation-Options.pdf

Béné, C., Arthur, R., Norbury, H., Allison, E. H., Beveridge, M., Bush, S., ... & Williams, M. (2016). Contribution of fisheries and aquaculture to food security and poverty reduction: assessing the current evidence. *World development*, *79*, 177-196. https://doi.org/10.1016/j.worlddev.2015.11.007

Bennett, N.J., Blythe, J., White, C.S. and Campero, C. (2019) 'Blue growth and blue justice', *Marine Policy*, 108, 103695. https://doi.org/10.1016/j.marpol.2019.103695

Berkes, F., Colding, J. and Folke, C. (2003) *Navigating social-ecological systems: Building resilience for complexity and change*. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511541957

Boyd, C.E., McNevin, A.A. and Davis, R.P. (2020) 'The contribution of fisheries and aquaculture to global protein supply', *Food Security*, 12, pp. 865–877.

Campbell, B. M., Beare, D. J., Bennett, E. M., Hall-Spencer, J. M., Ingram, J. S., Jaramillo, F., ... & Shindell, D. (2017). Agriculture production as a major driver of the Earth system exceeding planetary boundaries. *Ecology and society*, *22*(4). https://doi.org/10.5751/ES-09595-220408

Charisiadou, S., Halling, C., Jiddawi, N., von Schreeb, K., Gullström, M., Larsson, T., & Nordlund, L. M. (2022). Coastal aquaculture in Zanzibar, Tanzania. *Aquaculture*, *546*, 737331. https://doi.org/10.1016/j.aquaculture.2021.737331

Cheung, W. W., Jones, M. C., Reygondeau, G., Stock, C. A., Lam, V. W., & Frölicher, T. L. (2016). Structural uncertainty in projecting global fisheries catches under climate change. *Ecological Modelling*, *325*, 57-66. https://doi.org/10.1016/j.ecolmodel.2015.12.018

Chopin, T., Cooper, J. A., Reid, G., Cross, S., & Moore, C. (2012). Open-water integrated multi-trophic aquaculture: Environmental biomitigation and economic diversification of fed aquaculture by extractive aquaculture. *Reviews in Aquaculture*, 4(4), 209–220. https://doi.org/10.1111/j.1753-5131.2012.01074.x

Cinner, J. E., McClanahan, T. R., Graham, N. A., Daw, T. M., Maina, J., Stead, S. M., ... & Bodin, Ö. (2012). Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries. *Global Environmental Change*, *22*(1), 12-20. https://doi.org/10.1016/j.gloenvcha.2011.09.018

Costello, C., Cao, L., Gelcich, S., Cisneros, M. A., Free, C. M., Froehlich, H. E. & Lubchenco, J. (2023). The future of food from the sea. In *The Blue Compendium: From Knowledge to Action for a Sustainable Ocean Economy* (pp. 1-14). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-16277-0_1

Cotas, J., Leandro, A., Pacheco, D., Gonçalves, A.M.M. and Pereira, L. (2020). A comprehensive review of the nutraceutical and therapeutic applications of red seaweeds (Rhodophyta), Life, 10(19). https://doi.org/10.3390/life10030019

Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F. N., & Leip, A. J. N. F. (2021). Food systems are responsible for a third of global anthropogenic GHG emissions. *Nature food*, *2*(3), 198-209. https://doi.org/10.1038/s43016-021-00225-9

© 2026 The Authors. Published under CC BY 4.0. | https://doi.org/10.66529/book.9786277945039.2026.ch7

Development Initiatives (2024) *Global Nutrition Report 2024: Strengthening nutrition resilience*. Bristol: Development Initiatives.

Duarte, C. M., Losada, I. J., Hendriks, I. E., Mazarrasa, I., & Marbà, N. (2013). The role of coastal plant communities for climate change mitigation and adaptation. *Nature climate change*, *3*(11), 961-968. https://doi.org/10.1038/nclimate1970

Duarte, C. M., Wu, J., Xiao, X., Bruhn, A., & Krause-Jensen, D. (2017). Can seaweed farming play a role in climate change mitigation and adaptation?. *Frontiers in Marine Science*, *4*, 100. https://doi.org/10.3389/fmars.2017.00100

Duarte, C. M., Agusti, S., Barbier, E., Britten, G. L., Castilla, J. C., Gattuso, J. P., ... & Worm, B. (2020). Rebuilding marine life. *Nature*, *580*(7801), 39-51. https://doi.org/10.1038/s41586-020-2146-7

Duarte, C. M., Bruhn, A., & Krause-Jensen, D. (2021). A seaweed aquaculture imperative to meet global sustainability targets. *Nature Sustainability*, 5(3), 185–193. https://doi.org/10.1038/s41893-021-00773-9

Food and Agriculture Organization of the United Nations (FAO). (2016). *The State of World Fisheries and Aquaculture 2016. Contributing to Food Security and Nutrition for All*. Rome: FAO.

Food and Agriculture Organization of the United Nations (FAO). (2022). *The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation*. Rome: FAO. https://doi.org/10.4060/cc0461en

Food and Agriculture Organization of the United Nations (FAO). (2024). *The State of World Fisheries and Aquaculture 2024. Blue Transformation in Action*. Rome: FAO. https://doi.org/10.4060/cd0683en

Food and Agriculture Organization of the United Nations (FAO), International Fund for Agricultural Development (IFAD), United Nations Children's Fund (UNICEF), World Food Programme (WFP), & World Health Organization (WHO). (2025). *The State of Food Security and Nutrition in the World 2025 – Addressing High Food Price Inflation for Food Security and Nutrition*. Rome: FAO. https://doi.org/10.4060/cd6008en

Froehlich, H. E., Jacobsen, N. S., Essington, T. E., Clavelle, T., & Halpern, B. S. (2018). Avoiding the ecological limits of forage fish for fed aquaculture. *Nature Sustainability*, 1(6), 298–303. https://doi.org/10.1038/s41893-018-0077-1

Froehlich, H. E., Afflerbach, J. C., Frazier, M., & Halpern, B. S. (2019). Blue growth potential to mitigate climate change through seaweed offsetting. *Current Biology*, 29(18), 3087–3093. https://doi.org/10.1016/j.cub.2019.07.041

Garcia, S.M. and Rosenberg, A.A. (2010) 'Food security and marine capture fisheries', *Philosophical Transactions of the Royal Society B*, 365(1554), pp. 2869–2880. https://doi.org/10.1098/rstb.2010.0171

Golden, C. D., Allison, E. H., Cheung, W. W. L., Dey, M. M., Halpern, B. S., McCauley, D. J., Smith, M., Vaitla, B., Zeller, D., & Myers, S. S. (2016). Nutrition: Fall in fish catch threatens human health. *Nature*, 534(7607), 317–320. https://doi.org/10.1038/534317a

Golden, C. D., Koehn, J. Z., Shepon, A., Passarelli, S., Free, C. M., Viana, D. F., Matthey, H., Eurich, J. G., Gephart, J. A., Fluet-Chouinard, E., Nyboer, E. A., Lynch, A. J., Kjellevold, M., Bromage, S., Charlebois, P., Barange, M., Vannuccini, S., Cao, L., Kleisner, K. M., Rimm, E. B., Danaei, G., DeSisto, C., Kelahan, H., Fiorella, K. J., Little, D. C., Allison, E. H., Fanzo, J., & Thilsted, S. H. (2021). Aquatic foods to nourish nations. *Nature*, 598(7880), 315–320. https://doi.org/10.1038/s41586-021-03917-1

Gutiérrez, N.L., Hilborn, R. and Defeo, O. (2011) 'Leadership, social capital and incentives promote successful fisheries', *Nature*, 470, pp. 386–389. https://doi.org/10.1038/nature09689

Hicks, C. C., Cohen, P. J., Graham, N. A., Nash, K. L., Allison, E. H., D'Lima, C., ... & MacNeil, M. A. (2019). Harnessing global fisheries to tackle micronutrient deficiencies. *Nature*, *574*(7776), 95-98.. https://doi.org/10.1038/s41586-019-1592-6

High Level Panel of Experts (HLPE). (2014). Sustainable fisheries and aquaculture for food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome: FAO.

Hoegh-Guldberg, O., Northrop, E., & Lubchenco, J. (2019). The ocean is key to achieving climate and societal goals. *Science*, *365*(6460), 1372-1374. https://www.researchgate.net/profile/Jane-Lubchenco/publication/336049116_The_ocean_is_key_to_achieving_climate_and_societal_goals/links/61294f5ac69a4e48795ff8b2/The-ocean-is-key-to-achieving-climate-and-societal-goals.pdf

Hurd, C.L., Harrison, P.J., Bischof, K. and Lobban, C.S. (2020) *Seaweed ecology and physiology*. 2nd edn. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9781139192637

Intergovernmental Panel on Climate Change (IPCC). (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC). (2023). *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva: IPCC. https://doi.org/10.59327/IPCC/AR6-9789291691647

Kittinger, J. N., Finkbeiner, E. M., Ban, N. C., Broad, K., Carr, M. H., Cinner, J. E., Gelcich, S., Cornwell, M. L., Koehn, J. Z., Basurto, X., Fujita, R., Caldwell, M. R., & Crowder, L. B. (2013). Emerging frontiers in social-ecological

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systems research for sustainability of small-scale fisheries. *Current Opinion in Environmental Sustainability*, 5(3–4), 352–357. https://doi.org/10.1016/j.cosust.2013.06.008

Msuya, F. E. (2006). The impact of seaweed farming on the social and economic structure of seaweed farming communities in Zanzibar, Tanzania. Zanzibar: Institute of Marine Sciences, University of Dar es Salaam.

Msuya, F.E. and Hurtado, A.Q. (2017) 'The role of women in seaweed aquaculture…', *European Journal of Phycology*, 52(4), pp. 482–494. https://doi.org/10.1080/09670262.2017.1365174

Naylor, R. L., Hardy, R. W., Buschmann, A. H., Bush, S. R., Cao, L., Klinger, D. H., Little, D. C., Lubchenco, J., Shumway, S. E., & Troell, M. (2021) 'A 20-year retrospective review of global aquaculture', *Nature*, 591, pp. 551–563. https://doi.org/10.1038/s41586-021-03308-6

OECD (2008, 2023) *Fisheries and composite indicator reports*. Paris: OECD Publishing.

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science*, 325(5939), 419–422. https://doi.org/10.1126/science.1172133

Pauly, D. and Zeller, D. (2016) 'Catch reconstructions reveal global fisheries decline', *Nature Communications*, 7, 10244. https://doi.org/10.1038/ncomms10244

Pikitch, E. K., Santora, C., Babcock, E. A., Bakun, A., Bonfil, R., Conover, D. O., Dayton, P., Doukakis, P., Fluharty, D., Heneman, B., Houde, E. D., Link, J., Livingston, P. A., Mangel, M., McAllister, M. K., Pope, J., & Sainsbury, K. J. (2004). Ecosystem-based fishery management. *Science*, 305(5682), 346–347. https://doi.org/10.1126/science.1098222

Tacon, A. G. J., & Metian, M. (2015). Feed matters: Satisfying the feed demand of aquaculture. *Reviews in Fisheries Science & Aquaculture*, 23(1), 1–10. https://doi.org/10.1080/23308249.2014.987209

Thilsted, S. H., Thorne-Lyman, A., Webb, P., Bogard, J. R., Subasinghe, R., Phillips, M. J., & Allison, E. H. (2016). Sustaining healthy diets: The role of capture fisheries and aquaculture for improving nutrition in the post-2015 era. *Food Policy*, 61, 126–131. https://doi.org/10.1016/j.foodpol.2016.02.005

Troell, M., Joyce, A., Chopin, T., Neori, A., Buschmann, A. H., & Fang, J.-G. (2009). Ecological engineering in aquaculture — Potential for integrated multi-trophic aquaculture (IMTA) in marine offshore systems. *Aquaculture*, 297(1–4), 1–9. https://doi.org/10.1016/j.aquaculture.2009.09.010

Troell, M., Naylor, R. L., Metian, M., Beveridge, M., Tyedmers, P. H., Folke, C., Arrow, K. J., Barrett, S., Crépin, A.-S., Ehrlich, P. R., Gren, Å., Kautsky, N., Levin, S. A., Nyborg, K., Österblom, H., Polasky, S., Scheffer, M., Walker, B. H., Xepapadeas, T., & de Zeeuw, A. (2014). Does aquaculture add resilience to the global food system? *Proceedings of the National Academy of Sciences*, 111(37), 13257–13263. https://doi.org/10.1073/pnas.1404067111

Troell, M., Costa-Pierce, B., Stead, S., Cottrell, R. S., Brugère, C., Farmery, A. K., Little, D. C., Strand, Å., Pullin, R., Soto, D., Beveridge, M., Salie, K., Dresdner, J., Moraes-Valenti, P., Blanchard, J., James, P., Yossa, R., Allison, E., Devaney, C., & Barg, U. (2023). Perspectives on aquaculture's contribution to the Sustainable Development Goals for improved human and planetary health. *Journal of the World Aquaculture Society*, 54(2), 251–342. https://doi.org/10.1111/jwas.12946

UNEP (2021) *Making peace with nature*. Nairobi: United Nations Environment Programme. https://www.unep.org/resources/making-peace-nature

United Nations (2024) *World population prospects 2024: Summary of results* (UN DESA/POP/2024/TR/NO. 9). New York: UN DESA. https://population.un.org/wpp

van Dijk, M., Morley, T., Rau, M. L., & Saghai, Y. (2021). A meta-analysis of projected global food demand and population at risk of hunger for the period 2010–2050. *Nature Food*, 2(7), 494–501. https://doi.org/10.1038/s43016-021-00322-9

World Bank (2017–2025) Various blue economy and fisheries reports. Washington, DC: World Bank.

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CHAPTER 08

Food Price Volatility and Policy Responses

Zaki Rauf[1,*], Ayesha Rouf[2,*], Abdullah Hammad[3], Tahira Sadaf[2] & Muhammad Khalid Bashir[2,4]
[1]National Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan
[2]Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad, Pakistan
[3]National Business School, The University of Faisalabad, Faisalabad, Pakistan
[4] Policy, Advocacy, and Outreach, Pak-Korea Nutrition Center, University of Agriculture, Faisalabad, Pakistan
Corresponding authors' email: zakirauf88@gmail.com, 2013ag3509@uaf.edu.pk

Abstract

The issue of food price volatility poses an important problem regarding food security, economic stability, and well-being of households in developing and emerging economies like Pakistan. This chapter is an exhaustive analysis of existing literature about food price volatility including factors that affect it and consequences for different sectors, based on evidence from the international, regional, and Pakistani context. Volatility can be affected by supply side issues, which include climatic variations, production-related problems, along with demand side and macroeconomic conditions. Based on the literature review of existing research, one can conclude that food price variability has a negative impact on household well-being, food security, and nutrition outcomes, especially concerning more vulnerable groups. With the increase in prices, there is a change in consumers' behavior; specifically, people switch to a less diverse diet with lower quality products. Food price variability also influences the economy by affecting industries and macroeconomic stability. However, there are several approaches policymakers may adopt to overcome this problem, including subsidies, tariffs, and other policy tools. The chapter points out important areas requiring further research, such as the gender issue and disparities between urban and rural areas. The importance of evidence-based policymaking that considers an integrated approach to food security is highlighted.

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1. Introduction

The problem of volatile food prices has increasingly become a major issue for scholars and policymakers owing to its wide-ranging consequences on the security, stability, and wellbeing of communities. The prices of food commodities are inherently prone to fluctuations. Yet, the current era has seen more focus placed on unpredictable and sudden swings in food prices. Such fluctuations are caused by a variety of factors, both periodic, such as seasons, and unpredictable, including climatic factors, macroeconomic instabilities, and policy shifts. According to scholarly research, weather-induced production shocks, global market demand, and institutions are some of the principal sources of such fluctuations (Amolegbe *et al*., 2021).

The effect of food price volatility becomes even more apparent in developing countries because people living in these countries spend most of their earnings on food purchases. For example, food prices are known to influence both food security and nutrition levels in poor countries. Research demonstrates that an unanticipated rise in the price of food products results in less dietary diversity and higher food spending ratios, particularly in poorer families. This demonstrates the existence of a direct correlation between food prices and food security and nutrition rates, showing that food price volatility affects more than just market performance (Gilbert & Morgan, 2010).

Regarding economics, the issue of price volatility for food products could be analyzed in terms of the supply and demand equilibrium model, where the changes in production or consumption could be transformed into price changes based on the responsiveness of the market. The low supply and demand elasticity in the short run, coupled with poor storage facilities and imperfect markets, would exacerbate the impact of shocks in

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developing nations. Moreover, the process of globalization within the international market could also expose the domestic market to price volatility within the international market, making them even more vulnerable to external shocks (Timmer, 2010; Gilbert & Morgan, 2010; Headey & Fan, 2010; Ibrahim, 2015).

Considering the far-reaching impact of this problem, different tactics have been employed by governments and policy makers, such as subsidies, trading policies, and creation of strategic food reserves. Yet, their efficacy has been questioned since most of these strategies offer temporary solutions without tackling the core problem. Food price fluctuations are indeed complicated in nature, thereby necessitating an analytical and empirical approach to the problem (Dorward, 2012; Wright, 2011).

Within the framework of Pakistan, the issue of food price volatility becomes even more pressing owing to the inefficiencies within the agriculture sector, sensitivity to weather conditions, and vulnerability to shocks from international prices. It becomes important to analyze the factors causing the volatility of food prices, the consequences thereof, and possible ways to address the issues. The purpose of this chapter is to make such an analysis through the review of the available literature related to the issue of volatility of food prices, paying special attention to Pakistan and developing countries (Ismail *et al*., 2017; Ahmad *et al*., 2024).

Food inflation also has wider effects on the overall well-being of humans, especially in underdeveloped countries. Food inflation leads to restricted access to healthy food which can lead to ill health and low life expectancy. It is more problematic in countries that do not have economic strength. When it comes to Pakistan, there are structural and governance issues present in the country, and thus food inflation leads to many problems other than food insecurity and welfare of households Mimouni *et al*. (2026).

1.1. Problem Statement

Food price volatility is increasingly being recognized as one of the biggest problems faced by food systems around the world, especially in developing nations that are more sensitive to price fluctuations. Price volatility in food markets has a direct impact on food availability, accessibility, and food security. People who are already struggling financially may be forced into extreme poverty due to rising food costs, making it more difficult for them to meet their basic needs. Even though several measures have been implemented, food price volatility remains an unresolved issue.

On the other hand, the factors behind food price volatility are intricate and multidimensional in nature. While there exists a lot of literature on these aspects, the conclusions reached thus far seem disjointed across various geographical locations and methods used. In particular, what appears to be lacking is an integration of the findings from global, regional, and national perspectives, which would yield a holistic perspective on why prices fluctuate, and how policies can mitigate this effect.

Such a gap underscores the importance of carrying out an assessment of the literature that is both systematic and well organized, to ensure evidence synthesis, gaps identification, and appropriate policy advice based on this review. This chapter seeks to carry out an evaluation of such dynamics with special emphasis on the role played by policy measures.

1.2. Scope and Objectives of the Chapter

In this chapter, a comprehensive literature review is conducted focusing on food price volatility and the corresponding policies employed to address the issue at different geographical scales namely, at the international, regional, and national levels. Literature on the drivers of food price volatility, its impacts on food security, nutrition, and household well-being, as well as the efficiency of various measures designed to reduce price instability, will be reviewed. This chapter reviews literature from theoretical and empirical perspectives based on academic journals, review articles, and related policy studies published in English. Special consideration will be given to evidence from both advanced and developing economies, especially LMICs.

This study focuses especially on context-specific information regarding the experiences of Pakistan, as well as similar developing nations, to gain insights into local issues and appropriate policy measures. Regarding

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methodology, the current chapter will conduct a systematic review based on PRISMA standards to provide a scientific and structured process of reviewing literature. This study uses secondary data only and refrains from collecting any new data or conducting econometric analyses.

Objectives

The main objective of this chapter is to systematically review and synthesize the existing literature on food price volatility and policy responses to develop a comprehensive understanding of its drivers, impacts, and policy implications.

Specifically, the study aims to:

1. Examine the major drivers of food price volatility, including supply-side shocks, demand-side pressures, climate variability, and market structure dynamics.
2. Analyze the impacts of food price volatility on food security, nutrition, and household welfare, with particular emphasis on vulnerable populations in developing countries.
3. Evaluate the effectiveness of key policy interventions, such as trade policies, subsidies, price controls, and strategic food reserves, in stabilizing food prices.
4. Identify research gaps and synthesize evidence to provide policy-relevant insights for improving food system resilience and strengthening responses to food price volatility.

2. Literature Review

The issue of food price volatility has emerged as a rather complicated matter in global and domestic food chains, especially for developing countries due to their greater susceptibility to price movements. Numerous recent studies show that climate variability, disruptions in supply chains, and production risks continue playing a crucial role in causing volatility in food markets. Unfavorable weather and changing climatic trends have made the volume of agricultural products uncertain, which has resulted in unpredictable supplies and higher volatility in prices (Kalkuhl *et al*., 2016; Ben Abdallah, 2024; Anderl & Caporale, 2025). Therefore, food price volatility seems to be not a passing issue, but a structural one caused by environmental changes.

However, at the same time, one should bear in mind that food price changes do not occur separately from other economic developments taking place at the global level. Food price dynamics have become more vulnerable to global economic forces due to increasing linkages between the domestic and international markets. Price changes in energy, foreign exchange rate, and world trade regimes have affected domestic food prices in a substantial way. The emerging linkages between energy and food markets facilitated by biofuel production have played an important role in making the transfer of price shocks more efficient, which has contributed to increased volatility in food prices (Nazlioglu, 2011; Dorward, 2013).

In addition to the above-mentioned extrinsic factors, intrinsic market-related factors add another dimension to market prices making them highly volatile particularly in developing nations. Structural issues like poor market integration, inadequate storage infrastructure, and lack of market information make the market players less responsive to any price shifts. Consequently, small disturbances end up having a significant impact on the prices of the domestic market. The conclusion from the above discussion is that besides extrinsic factors, there are intrinsic factors also behind price volatility.

Regarding these difficulties, reactions to policy options have garnered growing interest in recent research work. The government usually resorts to implementing policies such as price regulation, subsidies, and trade prohibitions when there is an urgent need to control rapidly rising food prices. However, while these actions may offer temporary assistance, their usefulness has been questioned. There is substantial proof showing that the use of these policies may have adverse effects in case they are maintained for long periods (Gouel, 2013; Kalkuhl *et al*., 2016).

On the other hand, newer research tends to focus on the need for policies that are sustainable and adaptive. The creation of systems for improving agricultural productivity, strengthening logistical chains, and

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improved market transparency have been identified as vital elements of an adaptive strategy for responding to food price volatility. Additionally, social safety nets in the form of conditional cash transfers and other forms of food aid are important for protecting the vulnerable without affecting the functioning of markets (Abdullah *et al*., 2019; Karagöl, 2025).

It is also emerging that digital technologies and information systems have a part to play in making food markets more stable. Information about markets helps in reducing uncertainty and facilitating price transmission (Aker *et al*., 2017). It is clear that technology opens up a whole new area of policy making that has not been exploited before.

In conclusion, the literature shows a trend toward a consensus that dealing with food price volatility should follow an integrated approach to policies. In the event of any crisis that calls for immediate actions, long-term approaches aimed at improving market systems and increasing institutional capacity become critical.

2.1. Conceptual Framework

Food price volatility is a complex concept that is affected by multiple factors, such as economic, environmental, and institutional drivers. The present research paper aims to define food price volatility as an effect resulting from interactions between supply-side and demand-side shocks as well as market failures, which, in turn, are affected by certain policy decisions.

Supply-side aspects include climate change, production shocks, and disruptions to food supply chains. These factors have a direct impact on the amount of food available to consumers and result in food price volatility. In addition to supply-side drivers, there are demand-side elements influencing food price volatility, namely population changes, income variations, and consumption behavior.

The model also considers global economic connections, acknowledging that national food prices have become increasingly vulnerable to influences from outside, including international trade policies, currency movements, and changes in the cost of energy. This interconnectedness of the global economy and the domestic economy make food prices even more volatile.

Moreover, structural and institutional elements are vital in determining the degree of price volatility. Poor market integration, insufficient storage facilities, and lack of market information affect food systems' efficiency and increase volatility. Structural problems are especially significant in underdeveloped nations, which still lack strong institutions.

An important element of this model is the importance of the role played by the policies themselves, acting as mitigating and, in some instances, amplifying agents. The immediate measures that might be taken as policies include things like price ceilings and floors, subsidy programs, and even trade restrictions. These are put into effect to help control and regulate markets during times of crisis, though whether these measures work or not will depend on their formulation and implementation.

In the end, the framework connects food price volatility to the individual or family-level results (see Figure 8.1), including food insecurity and economic welfare. Price changes influence food availability, dietary composition, and health status, more particularly in poor communities. Such an understanding offers a broad framework for examining the root cause of food price volatility and its effects, while underlining the importance of policy in this process.

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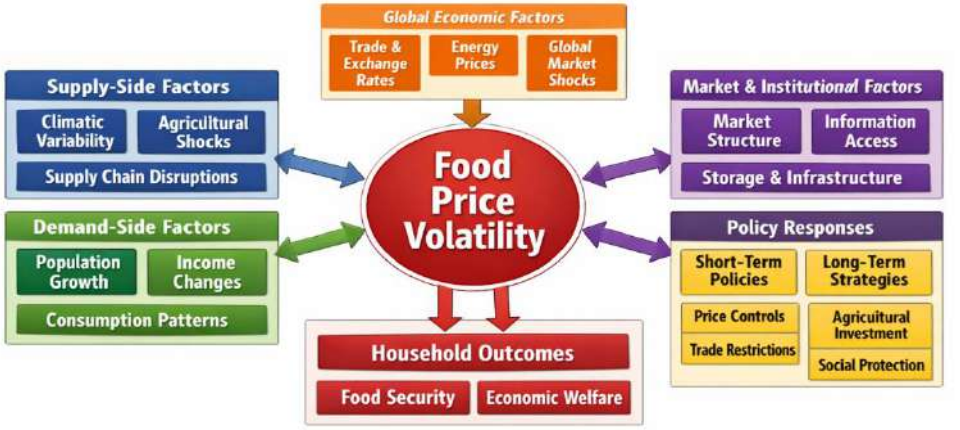

Figure 8.1: Conceptual Framework of Food Price Volatility

3. Methodological Approach

3.1. Research Design

This study utilizes the method of systematic review as a means of synthesizing the current literature on food price volatility and policy interventions to address the problem. Specifically, the review will adhere to the PRISMA protocol that helps create a well-planned and repeatable review process. Using this methodology, the paper will be able to systematically identify, select, and evaluate literature to get a clear picture of the field. Systematic review is especially valuable in analyzing how the literature describes the factors contributing to, as well as the consequences of, food price volatility and policy interventions.

3.2. Data Sources and Search Strategy

The process of obtaining relevant literature was achieved through conducting a systematic search on reputable academic databases, such as Scopus, Web of Science, PubMed, and Science Direct. These sources were used since they provide quality literature after going through a process of being peer-reviewed. Additionally, Google Scholar and the list of references from chosen articles were also considered for the purpose of minimizing the risk of missing any relevant articles.

A search strategy was developed based on specific keywords and Boolean operators that allowed the retrieval of a large body of relevant literature. The key search terms used were "food price volatility" or "food price fluctuations" combined with terms like "food security," "agricultural markets," "price transmission," "policy interventions," and "shocks to food systems." The terms were modified slightly depending on which database was being used.

3.3. Inclusion and Exclusion Criteria

A systematic methodology was applied while selecting studies through applying appropriate inclusion and exclusion criteria to identify relevant research. Studies were chosen if they belonged to scholarly journal publications and dealt with food prices volatility, food security issues, or any other relevant policies. There were different kinds of studies considered, such as empirical studies, theoretical studies, and reviews; however, these had to be written in English. A wide range of views was presented by including the studies not only worldwide but also regional, especially those relating to low- and middle-income countries and Pakistan.

However, some papers were excluded from this review to keep up the high level of research conducted. The criteria for their exclusion included: non-peer reviewed sources, such as preprints and grey literature;

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duplicates; those which have nothing to do with the topic of discussion (i.e., food prices volatility); and studies that did not present a good methodology or made little contribution empirically.

3.4. Study Selection Process

Studies selection process entailed a sequential and systematic identification and selection process. Initially, all relevant articles were identified in the database search process based on the use of predefined keywords. Afterward, duplicates were eliminated to ensure that there was no repetition.

Subsequently, the remaining articles were screened based on their titles and abstracts to determine whether they fulfilled the set criteria. Articles that were relevant were read and evaluated with respect to their suitability and methodological soundness. Articles that fulfilled all criteria were finally selected for the study. The entire study selection process is illustrated in the PRISMA flow chart (Figure 2).

3.5. Data Extraction and Management

Study selection is shown in Figure 8.2 in the form of a PRISMA flowchart. To be consistent and accurate, the data from the selected studies were systematically collected through a standardized template. The following items were included in the data extraction: author(s) and year of publication, study site and setting, sources of data, methodology employed, key variables studied, analysis techniques used, and major results pertaining to food price instability.

In addition, any implications of policies that may be derived from the findings of the research were also considered. These extracted data were systematically categorized to facilitate comparisons between different studies and enable a thematic analysis to be performed. Figure 8.2 shows the procedures employed for selecting the articles used for the book chapter. Identification is the first phase, which yielded 100 pieces of data, including 90 from electronic databases and 10 from other sources. The number of pieces of data that did not overlap was 70 after duplicates were excluded.

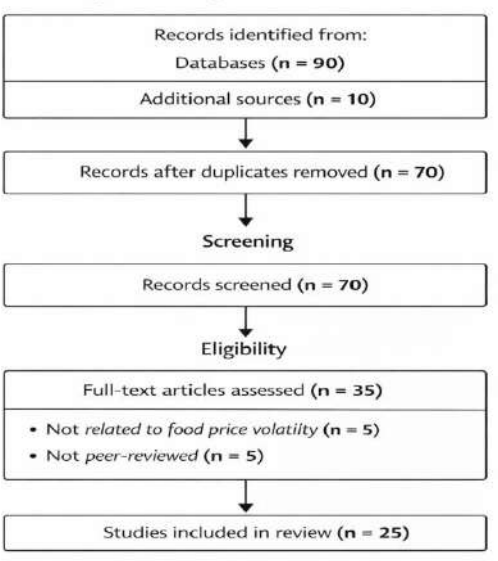
Records identified from:
Databases (n = 90)
Additional sources (n = 10)
Records after duplicates removed (n = 70)
Screening
Records screened (n = 70)
Eligibility
Full-text articles assessed (n = 35)
• Not related to food price volatility (n = 5)
• Not peer-reviewed (n = 5)
Studies included in review (n = 25)

Figure 8.2: Prisma Flow Diagram of the Study Selection Process

The 70 records were then further filtered based on their title and abstract to identify whether they are relevant to the research topic. After the filtering process, 35 articles were identified to be appropriate for full text analysis. In the eligibility process, some articles were excluded based on certain grounds. Five

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articles were excluded as they did not concern food price volatility while another five articles were excluded as they were not peer-reviewed. A total of 25 articles satisfied all the criteria and were therefore included in the review process. The number highlights the systematic process from the initial list of records to the final selected articles in the book chapter.

3.6. Quality Assessment

The quality of the chosen articles was also critically evaluated to include only the articles with valid findings in the discussion. The critical evaluation was done based on various factors, which included the research methodology employed, the reliability of the data used, and the method of analysis, among others. Much emphasis was also placed on the type of econometric models used in studies conducted. Econometric models, such as ARDL, GARCH, and VAR models, were highly prioritized. The relevance of the findings to policymaking was another crucial aspect considered. Those articles that were methodologically sound received more emphasis, whereas those that had many drawbacks were eliminated.

3.7. Data Synthesis

As the selected studies varied in methodology, data sources, and geographic location, the narrative synthesis method was applied to present the information. The information gathered was then grouped into important themes that would help explain the topic better. The important themes related to the topic were the reasons behind the instability of food prices such as supply and demand forces and the role of markets. This literature review also focused on various forms of policy interventions, such as those relating to trade, subsidies, and prices, and how they influence food security and nutrition. Also, comparisons were made between various countries and regions to see if there were any common patterns and differences that existed. This also led to the identification of any research gaps that exist within this field.

4. Empirical evidence: case studies from Pakistan

4.1. Food Price Volatility Across Major Cities of Pakistan

Zehra and Fatima's (2019) study examines monthly price series of sixteen major food commodities such as wheat, rice, milk, eggs, and vegetables in fourteen major cities of Pakistan employing the GARCH (1,1), IGARCH (1,1) models, and standard deviations methods. Findings reveal the persistence and high heterogeneity of food prices' volatility in different regions, which implies varying behavior of food prices depending on regional demand and supply dynamics as well as market structures. The authors emphasize that special city-level policies might be needed to address the issues of food prices' volatility.

4.2. Impact of Food Price Volatility on Household Welfare

An empirical study by Zehra & Fatima (2022), which is relevant to the present research, investigated the effect of food price volatility on household welfare in urban settings based on the results of several waves of the Pakistan Social and Living Standards Measurement (PSLM/HIES). With the help of the fixed-effect model for pseudo-panel data, it was concluded that food price volatility had a negative effect on household welfare, especially in urban settings, by lowering the purchasing capacity and leading to deprivation.

4.3. Consumption Patterns and Price Effects in Pakistan

A wide range of empirical studies has established that food price changes in Pakistan are highly relevant to consumption behavior and welfare in general. According to Shabnam *et al*. (2023), there is an empirical link between food price increases and poverty in Pakistan, with increases in food prices correlating with higher poverty rates in low-income groups. As food prices increase, consumption patterns are adjusted in such a way that less food is consumed by households, and its quality deteriorates because more calories and fewer nutrients become available to people. This effect can be explained by the substitution between foods based on their cost and nutrient content; thus, the consumption adjustment leads to negative impacts on health and education. Particularly, it is important to point out that vulnerable population groups that include rural and poor households face serious difficulties due to the high share of food expenditures.

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Similarly, Abbas & Alnafrah (2024) investigate the spillover impact of the Russia-Ukraine war on food security in Pakistan and find empirical evidence showing that international price shocks impact the domestic market and change consumer consumption pattern in the country. Specifically, the authors report that increases in international prices of food result in unaffordability, which compels consumers to change their consumption basket by consuming more staple foods and less expensive imported foods. This is an example of how consumers make changes to their demand for products in reaction to an increase in prices of the products. Also, it becomes important to point out that shocks from the outside world may increase the vulnerabilities that Pakistan already faces because of its reliance on food imports and absence of adequate pricing policy.

When analyzed together, the above studies indicate that changes in prices either due to internal reasons or external shocks have a direct effect on consumer behavior within Pakistani households. Although the study conducted by Shabnam *et al*. (2023) deals mainly with the welfare aspect associated with the increase in prices, Abbas and Alnafrah (2024) look at the issue of global market integration and how it influences internal food consumption practices. Both studies lead to the same point that is, food price increases reduce welfare and limit diet choices.

In theoretical terms, this evidence is consistent with the demand theory and the idea of price elasticity of demand, indicating that with rising food prices, the quantity demanded declines, particularly with respect to non-essential and more expensive food products. These results are also consistent with the overall concept of food security, in which availability, access, and affordability play significant roles in influencing food consumption patterns. Within the specific case of Pakistan, where incomes have not grown significantly and household expenditures on food remain substantial, the vulnerability of households to fluctuations in food prices is further emphasized.

4.4. Drivers of Food Price Volatility in Pakistan

Fluctuations in food prices in Pakistan occur because of the presence of macroeconomic instability, cost-related issues for production, and market inefficiencies. According to Iram and Yousaf (2025), the fluctuations in food prices have significant relations with macroeconomic variables like the general level of inflation, changes in the exchange rate, and monetary policy actions. Inflation creates uncertainty in the cost of inputs and outputs, and the effects of these uncertainties spread to other sectors, including the industrial sector, resulting in poor economic performance. The cost of energy and fuel increases transportation costs, which are then transferred to the consumer. Consequently, price volatility does not only exist in agriculture but is also embedded in the economy as a whole.

Apart from macroeconomic variables, other structural and external variables have been seen to impact food price volatility in Pakistan significantly. Poor supply chain infrastructure, weak storage facilities, and fragmentation of the market result in inefficient transmission of food prices, leading to continued disparity in the food prices across various regions in the country. Variability in climatic conditions and production shocks tend to inhibit the consistent flow of agricultural products, thereby making prices susceptible to seasonal variations. On the other hand, the integration of Pakistan into the global market system makes the economy susceptible to international price shocks and foreign exchange rate fluctuations for imported food products.

4.5. Broader Economic Effects of Price Volatility

Although this is not an exclusive relationship, some studies have found that there is indeed a correlation between food price instability and economic performance. Some studies in the Pakistani industry have shown that there is a relationship between food prices and the performance of the manufacturing industries and the financial performance of the companies. There are implications that food price instability could affect economic performance apart from having implications on the welfare of the consumers (Khan & Shah, 2022). In periods of increasing food prices, there is a shift in the proportion of income spent on food items, leaving little or no room for other consumption. The reduction in demand will lead to reduced production by industry.

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This could affect the profitability of the companies. In addition, there is an increase in labor costs due to increasing wages because of inflation.

In addition, food price fluctuations cause macroeconomic uncertainty, which may undermine business confidence as well as planning and forecasting efforts in the industrial sector. As businesses struggle with unpredictable cost structures and demands, they will cut back on production or put off expansion plans. The result will be inefficient allocation of resources. There is thus a reciprocal relationship between macroeconomic instability and industrial performance, whereby macroeconomic instability influences industry performance and vice versa. From the foregoing discussion, it can be concluded that addressing the volatility in food prices is essential not just in securing food security at the household level but also in achieving macroeconomic stability.

4.6. Key Insights

Regional variability: Volatility in food prices does not occur uniformly in Pakistan but differs among regions, requiring policy measures to reflect these regional differences.

Household well-being consequences: Studies reveal that volatility has a negative effect on urban household well-being, especially for poor households.

Consumption patterns: Volatility may affect the consumption decisions made by households in response to food prices.

Macro determinants: National-level factors, including oil prices and interest rates, drive volatility, demonstrating the relationship between agriculture and macroeconomic policy.

Sectoral implications: Volatility in food prices affects other economic sectors, not just agriculture, including the industrial sector.

4.7. Analysis of Food Price Volatility and Policy Responses

Determinants and Theoretical Foundations of Food Price Volatility

Price instability for food is a multifaceted issue arising from the interplay between supply shocks, demand pressure, and the macroeconomic environment. There is empirical evidence that climate variability, variation in input prices, and agricultural supply chain disruptions play a significant role in price instability. Other demand-related variables like growing population, urbanization, and shifts in consumer behavior exacerbate the pressure. Theoretically, the above can be explained by applying concepts of supply and demand shock, price transmission, and market failures, whereby imperfect competition and poor regulations contribute to price instability. This is a common issue in the field of agricultural economics and food security, especially under the market equilibrium and price transmission approach (Timmer, 2008; Barrett & Bellemare, 2011).

Consistency and Divergence in Empirical Findings on Food Price Volatility

From the analysis of various research papers, it is evident that different findings have been drawn from various studies. All the studies show consistency in finding out that volatility in food prices has adverse effects on household welfare, food security, and nutrition. The level of effect differs between studies because the data used in the studies are different, as well as the approach used for conducting the analysis. Panel data and time-series data yield better results than cross-sectional data analysis.

Strength and Reliability of Evidence

When it comes to the quality of evidence, research that uses longitudinal household-level data and econometrics is more likely to be accurate. This method enables analysts to account for unobservable differences and dynamics among variables. On the other hand, empirical work that uses aggregate-level data or descriptive analysis might fail to provide precise explanations of welfare and consumption determinants. Nevertheless, robust empirical work may be subject to challenges like data availability, error of

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measurement, and informal trade issues, especially in developing countries such as Pakistan (Ivanic & Martin, 2008).

Comparison of Global and Pakistan Evidence

The comparison between global literature and the local situation in Pakistan brings out certain important differences. While global research points to the prevalence of food price volatility, its effects are felt more acutely in developing nations due to inadequate institutional support. In the case of Pakistan, people are highly responsive to changes in prices, especially low-income and rural residents. Urban dwellers experience higher vulnerability to variations in market prices, whereas rural dwellers face them from both production and consumption perspectives. This brings about the conclusion that while there may not be much difference in the direction of the effect on a global scale, the magnitude varies.

Policy Analysis and Effectiveness

In terms of policies, several measures have been employed by the government to reduce the volatility of food prices in Pakistan. These include subsidization, trade policy, price controls, and the use of strategic food reserves. The problem is, however, that most of these strategies have not always proven successful. For instance, while subsidization might be useful at certain times, it is likely to distort the market and discourage food production. In addition, price controls, although useful, might result in shortage of food supplies when not effectively done. Nevertheless, trade policies can be quite helpful in mitigating volatility, if the economy is able to cope with international prices.

Limitations of Existing Studies

One of the limitations of many of the research papers that have been used in the research is their failure to provide complete and accurate datasets. In many cases, the data sets utilized by the researchers in carrying out their study are very limited and fail to address the issue of intra-household behavior, gender, and informal trading in markets. There has also been very little emphasis placed on examining urban-rural inequalities and gender impact due to the fluctuations in food prices.

Research Gaps in Literature

There have been many publications in literature about food price volatility around the world. However, there is not much literature on the gender dimensions of food price volatility in the country of Pakistan, especially through panel data analysis at the household level. Also, there should be more attention towards the influence of volatility on women's utilization of time, decision-making authority, and nutrition. Apart from that, there is a need for further research regarding urban and rural differentials and informal food markets as determinants of volatility.

Analytical Synthesis and Key Insights

In conclusion, based on the integration of existing evidence, it becomes clear that food price volatility is determined by several underlying conditions and is associated with various consequences, depending on regions and people. Whereas the concepts of supply and demand shocks, price transmission mechanisms, and market failure can be considered adequate starting points for comprehending food price volatility, empirical data show the complexity of this matter. In comparative terms, Pakistan is characterized by greater risks and problems because of structural flaws within its food system.

However, conflicting results suggest that while all studies may agree regarding the detrimental effects of food price volatility on welfare and food security, the variation in results is mainly attributable to differences in methods and contexts. It seems that the importance of robust data and models is fundamental in estimating the full effects of food price volatility.

5. Conclusion

This chapter has thoroughly analyzed the subject matter, which has been accomplished through an in-depth review of literature on food price volatility from a global perspective as well as its Pakistani experience. It

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can be inferred from the discussion that food price volatility is a multifaceted issue whose causes and effects are rooted in a variety of factors ranging from climate, economics, and structural considerations.

This literature review further reveals that despite agreement in the literature about the negative consequences associated with food price instability, there are considerable disparities in both the extent of these impacts and their transmission mechanisms owing to differences in methodology and location, among others. The policies adopted thus far in Pakistan have not been fully successful since they do not tackle the root cause of instability.

In general, there is the need for a more holistic approach to managing food price volatility and minimizing negative effects on food security. Improvements in terms of empirical studies and better data collection are some of the necessary approaches to achieving the goal of food security.

The effects of volatility on food prices also go beyond economics, influencing the welfare of individual households as well as their food security and nutrition status. With rising food prices, people will find that their real income is falling and hence will be forced to change their consumption behavior, especially poor households. In doing so, poorer households will likely turn to foods that are cheaper but nutritionally poor and thus affecting the quality of nutrition intake among households. Indeed, there is enough evidence to show that certain groups, such as rural households and poor urban households, are more vulnerable than others.

6. Policy Directions and Recommendations

Food price volatility continues to pose a serious issue for developed and developing nations, especially in terms of the serious impact that it has on developing countries like Pakistan. Volatility occurs due to a number of reasons, ranging from production issues, such as weather changes and interruptions in agricultural activities, to consumption factors as well as macroeconomic variables like inflation and fuel prices. In addition to all these factors, structural inefficiencies associated with food supply chain management contribute significantly to price volatility. These phenomena may be better understood by looking at concepts such as supply and demand shocks, price transmission, and market failure.

In order to deal with the issue of food price volatility, a wide-ranging and multifaceted policy framework needs to be established. The first step towards achieving this goal would be to improve the level of agricultural productivity by investing in R&D, improving irrigation, and adopting climate-resistant methods of cultivation.

Furthermore, the development of better market infrastructure and supply chains is crucial for overcoming inefficiencies and post-harvest losses. By creating more storage and transport capacities, it is possible to even out supply and stabilize prices.

Thirdly, measures need to be taken to ensure that there are increased transparency and regulation within the market. This includes developing better structures, collecting better information, and ensuring that there is more competition within the food market.

Fourthly, social protection measures need to be expanded and focused on protecting the poor from the negative consequences of volatile prices. Cash transfer programs, either conditional or unconditional, food safety nets, and subsidy schemes can play an important role in cushioning the welfare effects, especially for the poor.

Fifth, policy coherence is essential. Agricultural, trade, fiscal, and monetary policies need to be coordinated to prevent contradictory actions from increasing volatility. For instance, trade measures must be devised cautiously so as not to undermine efforts toward stable prices and integrated markets.

Lastly, there is the necessity to foster research and evidence-based policy making. With an increased supply of high-frequency and disaggregated data, policymakers would be able to monitor the food prices accurately and implement effective policy measures. Further research must address the implications of food price increases for specific genders, the variations in urban and rural areas, and the impact of informal markets.

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Conclusively, stabilizing and addressing food price volatility needs both immediate actions and longer-term solutions.

References

Abbas, S., & Alnafrah, I. (2024). Food security in Pakistan: Investigating the spillover effect of Russia-Ukraine conflict. *Sustainable Futures*, *8*, 100300. https://doi.org/10.1016/j.sftr.2024.100300.

Abdullah, Zhou, D., Shah, T., Ali, S., Ahmad, W., Din, I. U., & Ilyas, A. (2019). Factors affecting household food security in rural northern hinterland of Pakistan. https://doi.org/10.1016/j.jssas.2017.05.003

Ahmad, B., Badar, H., Gjølberg, O., & Mehdi, M. (2024). Price volatility and food security: Measurement and implications. *Food security in the developing world*, 165-189. https://doi.org/10.1002/9781119265214.ch8

Aker, J. C., Collier, P., & Vicente, P. C. (2017). Is information power? Using mobile phones and free newspapers during an election in Mozambique. *Review of Economics and Statistics*, *99*(2), 185-200. https://doi.org/10.1162/REST_a_00611

Amolegbe, K. B., Upton, J., Bageant, E., & Blom, S. (2021). Food price volatility and household food security: Evidence from Nigeria. *Food Policy*, *102*, 102061. https://doi.org/10.1016/j.foodpol.2021.102061

Anderl, C., & Caporale, G. M. (2025). Global food prices and inflation. *British Food Journal*, *127*(4), 1509-1525.https://bura.brunel.ac.uk/bitstream/2438/30769/5/FullText.pdf

Barrett, C. B., & Bellemare, M. F. (2011). Why food price volatility doesn't matter. *Foreign Affairs*. http://www.foreignaffairs.com/articles/67981/christopher-b-barrett-and-marc-f-bellemare/why-food-price-volatility-doesnt-matter

Ben Abdallah, M. (2024). *Factors of food security: agricultural price transmission and volatility spillovers* (Doctoral dissertation, Magyar Agrár-és Élettudományi Egyetem). https://doi.org/10.54598/004900

Dorward, A. (2012). The short-and medium-term impacts of rises in staple food prices. *Food security*, *4*(4), 633-645. DOI: 10.1007/s12571-012-0210-3

Dorward, A. (2013). Agricultural labour productivity, food prices and sustainable development impacts and indicators. *Food policy*, *39*, 40-50. https://doi.org/10.1016/j.foodpol.2012.12.003

Gilbert, C. L., & Morgan, C. W. (2010). Food price volatility. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1554), 3023-3034. Doi: 10.1098/rstb.2010.0139

Gouel, C. (2013). Optimal food price stabilisation policy. *European Economic Review*, *57*, 118-134. https://doi.org/10.1016/j.euroecorev.2012.10.003

Headey, D., & Fan, S. (2010). *Reflections on the global food crisis: How did it happen? How has it hurt? And how can we prevent the next one?* (Vol. 165). Intl Food Policy Res Inst. https://doi.org/10.2499/9780896291782rm165

Ibrahim, M. H. (2015). Oil and food prices in Malaysia: a nonlinear ARDL analysis. *Agricultural and Food Economics*, *3*(1), 2. https://doi.org/10.1186/s40100-014-0020-3

Iram, H., & Yousaf, A. (2025). Price Volatility and Financial Performance: Assessing the Impact of Food Prices on Pakistan's Industrial Sector. *Audit and Accounting Review*, *5*(2), 49-71. DOI: https://doi.org/10.32350/aar.52.03

Ismail, A., Ihsan, H., Khan, S. A., & Jabeen, M. (2017). Price volatility of food and agricultural commodities: A case study of Pakistan. *Journal of Economic Cooperation & Development*, *38*(3), 77 120.https://www.academia.edu/65528593/Price_Volatility_of_Food_and_Agricultural_Commodities_A_Case_Study_of_Pakistan

Ivanic, M., & Martin, W. 2008. *Implications of higher global food prices for poverty in low-income countries*. Agricultural Economics, 39(S1): 405–416. https://doi.org/10.1111/j.1574-0862.2008.00347.x

Kalkuhl, M., Von Braun, J., & Torero, M. (2016). *Food price volatility and its implications for food security and policy* (p. 626). Springer Nature. https://mpra.ub.uni-muenchen.de/72164/1/MPRA_paper_72164.pdf

Karagöl, V. (2025). Global Food Prices in the Shadow of Uncertainties, Risks and Volatilities. *İzmir İktisat Dergisi*, *40*(4), 1001-1019. https://doi.org/10.24988/ije.1554013

Khan, N. A., & Shah, A. (2022). An Empirical Analysis of the Prices of Selected Food Items Across Three Political administrations in Pakistan. https://doi.org/10.35536/lje.2022.v27.i2.a5

Mimouni, K., Temimi, A., Barkat, K., & Alsamara, M. (2026). Does food inflation affect how long we live? The role of economic development and political instability. *Journal of Economic Studies*, 1-20. https://doi.org/10.1108/JES-05-2025-0303

Nazlioglu, S. (2011). World oil and agricultural commodity prices: Evidence from nonlinear causality. *Energy policy*, *39*(5), 2935-2943. https://doi.org/10.1016/j.enpol.2011.03.001.

Shabnam, N., Aurangzeb, N., & Riaz, S. (2023). Rising food prices and poverty in Pakistan. *Plos one*, *18*(11), e0292071. https://doi.org/10.1371/journal.pone.0292071

Timmer, C. P. (2010). Reflections on food crises past. *Food policy*, *35*(1), 1-11. https://doi.org/10.1016/j.foodpol.2009.09.002

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Timmer, P. (2008). Agriculture and pro-poor growth: An Asian perspective. *Available at SSRN 1114155*. https://doi.org/10.2139/ssrn.1114155

Wright, B. D. (2011). The economics of grain price volatility. *Applied Economic Perspectives and Policy*, *33*(1), 32-58. https://doi.org/10.1093/aepp/ppq033

Zehra, N., & Fatima, A. (2019). FOOD PRICE VOLATILITY: A Comparative Analysis among Major Cities of Pakistan. *Pakistan Journal of Applied Economics*, *29*(1). http://www.aerc.edu.pk/wp-content/uploads/2019/06/Paper-911-NIGAR-IV-1.pdf

Zehra, N., & Fatima, A. (2022). Food price volatility and household welfare: A case study of major cities of Pakistan. *Business Review*, *17*(1), 85-105. https://doi.org/10.54784/1990-6587.1459

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CHAPTER 09

Trade Policy, Export Bans, and Import Dependence

Tahira Sadaf[1,*], Qasir Abbas[1], Nazia Tabasam[1], Neelam Rana[1], Saba Javed[1] & Hasan Zulfiqar[1]
[1]Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad, Pakistan
Corresponding author's email: tahira.sadaf@uaf.edu.pk

Abstract

This chapter examines the complex relationship between trade policy instruments, export restrictions, and food import dependence in South Asian countries. Drawing on international trade theory, food security governance frameworks, and empirical evidence from India, Pakistan, Bangladesh, Sri Lanka, and Nepal, the analysis explores how export bans and other trade restrictions affect domestic and international food markets. The chapter investigates price transmission mechanisms from global to local markets, evaluates the welfare consequences of export restrictions for producers and consumers, and analyzes the structural causes of import dependence. Attention is given to the food security crises triggered by the COVID-19 pandemic and the Russian invasion of Ukraine, which exposed vulnerabilities in global food supply chains. The chapter assesses how border measures affect food availability, prices, and diplomatic relations in the region. It offers strategic recommendations for balancing national food sovereignty with market integration, emphasizing the need for comprehensive risk management strategies, strengthened social safety nets, and enhanced regional cooperation to achieve sustainable food security outcomes.

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1. Introduction

Based on Chapter 9, which examined the causes, patterns, and implications of food price volatility, this chapter shifts focus to the function of trade policy in designing food security outcomes in less developed countries. While Chapter 9 highlighted how international and domestic price shocks impact producers and consumers. It also discussed the significance of policy responses to these shocks. In this scenario, trade policy appears to be an important tool using which governments try to stabilize domestic markets, manage risks, and ensure food supply during period of uncertainties.

The link trade policy with food security has become increasingly important, especially in the context of recurrent food crises and international peace situation globally. Trade policy instruments like tariffs and non-tariff barriers, subsidies, export bans, and import policies instantly affect the availability, accessibility, and stability of food supplies. In less developed economies, where agriculture is often constrained by low productivity, limited infrastructure, and climatic vulnerability, international trade plays a critical role in bridging the gap between national production and consumption. However, policy interventions intended at protecting domestic markets often create unintentional consequences that widen beyond domestic boundaries.

The worldwide food crises of 2007–08 and 2010–11, COVID-19 pandemic, the Russian invasion of Ukraine, and escalating climate-related disruptions provide distinct evidence of the complex role of trade policy related to food security. During these time periods, many nations impose export bans and other restrictive measures to protect domestic consumers from increasing international prices. Though such measures may provide short run relief, they tend to decrease international supply and increase price volatility. Empirical evidence shows that these policy measures significantly increase international food prices, and disproportionately affect net food importers (Headey, 2011; Anderson *et al*., 2014). According to the State

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of Food Security and Nutrition in the World 2025, the prevalence of undernourishment in Southern Asia declined to 11 percent in 2024, down from 13.9 percent in 2022, marking significant improvement driven largely by new data from India (FAO *et al*., 2025). However, nearly 80 percent of people facing hunger in Asia reside in South Asia, where moderate or severe food insecurity remains the highest among all subregions. Approximately 833.4 million people in Southern Asia faced moderate or severe food insecurity in 2024, with 387.7 million experiencing severe food insecurity. These statistics underscore the urgent need for a nuanced understanding of how trade policies affect food security outcomes across different country contexts.

Though the concepts such as food security and self-sufficiency have gained attention, however, according to Timmer (2010), complete self-sufficiency is not recommended to most developing countries. This chapter hence discusses trade policy functions as an outcome of price volatility as well as a structural determinant of food security by highlighting the need for coordinated trade strategy by minimizing distortions and enhancing resilience. Trade plays a twofold part in food security by stabilizing domestic supply shocks and/or causing vulnerability by increasing reliance on imports that might bring price volatility, supply imbalances, and exchange rate fluctuations (FAO, 2011; WTO, 2012).

This chapter will be addressing the key concept of price transmission and import dependence. Increased import bills during periods of high prices may result in fiscal balances and increase vulnerability to external shocks due to reliance on international markets (Ivanic & Martin, 2014). It provides a comprehensive examination of the complex relationships between trade policy instruments, particularly export bans and restrictions, and the growing phenomenon of food import dependence in South Asian countries.

1.1. Background and Global Relevance

Agricultural trade has long been recognized as a critical mechanism for achieving food security, particularly for countries with limited domestic production capacity or resource constraints. The theoretical foundations of comparative advantage suggest that international trade allows countries to specialize in commodities where they have relative efficiency advantages, thereby maximizing global welfare and enabling all trading partners to access food at lower costs than would be possible through domestic production alone (Ricardo, 1817; Heckscher & Ohlin, 1991). However, the practical application of these principles in the context of food security has proven far more complex than classical trade theory would suggest.

The global relevance of food trade has intensified under current geopolitical uncertainty. The war in Ukraine, which began in February 2022, disrupted global agricultural and food markets both directly through limiting supply from one of the world's largest grain exporters and indirectly through impacts of sanctions against Russia, spillover effects from energy and fertilizer markets, and domestic policies that countries implemented in pursuit of food security (Glauben *et al*., 2022). Ukraine's wheat production for the 2022/23 marketing year fell dramatically, while the Black Sea Grain Initiative, which temporarily allowed Ukrainian grain exports through blocked ports, was terminated by Russia in July 2023.

1.2. Food Crises and Trade Policy Responses

The historical record provides ample evidence of how major shocks can precipitate food crises with far-reaching consequences for human welfare and political stability. The 2007-2008 food price crisis, during which international prices for wheat and rice doubled within months, led to food riots in over 30 countries and pushed an estimated 130-155 million people into poverty (Ivanic & Martin, 2008; UNCTAD, 2008). Research by Martin and Anderson (2012) demonstrated that export restrictions imposed during this crisis were responsible for approximately 45 percent of the increase in rice prices and 29 percent of the increase in wheat prices, illustrating how beggar-thy-neighbor trade policies can exacerbate rather than ameliorate food security challenges.

The more recent crises triggered by COVID-19 and the Ukraine war have followed similar patterns, with countries responding to supply disruptions and price spikes by restricting exports in an attempt to insulate domestic markets from international volatility. India's ban on non-basmati rice exports in July 2023, imposed

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in response to rising domestic prices and concerns about El Niño impacts on production, exemplifies this pattern (Glauber & Mamun, 2023). The ban, which affected approximately 40 percent of globally traded rice, immediately raised international prices to their highest levels in more than a decade and created significant concerns about food security in African and Asian countries heavily dependent on Indian rice imports.

2. Trade Policy as a Food Security Governance Instrument

Trade policy occupies a central position in the architecture of food security governance, serving as both a tool for achieving domestic food security objectives and a mechanism for participating in the global food system. Understanding how trade policy functions as a governance instrument requires examining the theoretical foundations that link trade interventions to food security outcomes, the specific instruments available to policymakers, and the empirical evidence regarding their effectiveness in different country contexts.

2.1. Conceptual Framework: Trade Policy as Food Security Governance

The conceptualization of trade policy as a food security governance instrument draws on multiple theoretical traditions, including international trade theory, public economics, and institutional economics. From the perspective of trade theory, the fundamental rationale for government intervention in agricultural markets stems from market failures that prevent the efficient allocation of resources and the achievement of socially optimal outcomes (Tyers & Anderson, 1992). These market failures may include externalities associated with agricultural production, information asymmetries that impede market functioning, and the public good characteristics of certain aspects of food security.

The food security framework articulated by the Food and Agriculture Organization encompasses four dimensions: availability, access, utilization, and stability (FAO, 2008). Trade policy affects each of these dimensions in distinct ways. Import policies directly influence food availability by determining the quantity and price of food that can enter domestic markets from international sources. Export policies affect availability in importing countries while simultaneously influencing producer incentives and domestic price levels in exporting countries. The stability dimension of food security is particularly affected by trade policy, as restrictions on exports or imports can either buffer or amplify price volatility depending on their design and implementation.

2.2. Trade Policy Instruments and Their Effects

The instruments of agricultural trade policy can be categorized into several broad classes, each with distinct implications for food security. Tariffs, which are taxes imposed on imported goods, represent the most common form of border protection. By raising the domestic price of imported goods above their world price, tariffs protect domestic producers from foreign competition while simultaneously increasing costs for consumers. The magnitude of these effects depends on the height of the tariff and the responsiveness of domestic supply and demand to price changes (Anderson *et al*., 2013).

Table 9.1: Trade Policy Instruments and Their Effects on Food Security Dimensions

Instrument	Availability	Access	Stability	Notes
Import Tariffs	+ (if surplus)	- (higher prices)	Variable	Most common instrument
Import Quotas	++ (protects market)	-- (scarcity)	- (rigid)	More restrictive than tariffs
Export Bans	++ (domestic surplus)	+ (lower prices)	+ (short-term)	Controversial; limited WTO rules
Export Taxes	+ (some retention)	+ (moderate)	+ (flexible)	Less distorting than bans
Public Procurement	++ (stock building)	+ (if targeted)	++ (buffer)	Requires fiscal capacity

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Export restrictions, including bans, quotas, and taxes, have received particular attention in the context of food security. Unlike import restrictions, which are generally subject to WTO disciplines, export restrictions face limited multilateral regulations. Article XI:2(a) of the GATT permits temporary export prohibitions or restrictions to prevent or relieve critical shortages of foodstuffs, but this exception is vaguely worded and has proven difficult to enforce (Karapinar, 2011). The Agreement on Agriculture requires WTO members to give "due consideration" to the food security needs of importing countries before imposing export restrictions, but this obligation lacks enforcement mechanisms and has been widely ignored in practice (Anania, 2013).

2.3. International Experience in Developing Countries

The experience of different regions in using trade policy for food security provides valuable insights into what works and what does not do under different conditions. Asia, home to the world's largest populations and most significant concentrations of food insecurity, has developed distinctive approaches to food security governance that reflect its historical experiences, political economies, and institutional capacities.

In South Asia, the legacy of colonial-era famines and the experience of the Green Revolution have shaped food security policies that emphasize domestic production and strategic grain reserves. India, Pakistan, and Bangladesh have all maintained significant public sector involvement in grain markets, with government procurement, stockholding, and distribution playing central roles in their food security strategies (Mittal & Sethi, 2009). These countries have generally been reluctant to rely heavily on international trade for staple food security, preferring to maintain a degree of self-sufficiency even at significant economic cost.

3. How Global Prices Affect Local Markets of Food Grains

The cost of agricultural products has a significant impact on welfare and economic conditions of emerging countries. Block and Webb (2009) found that poor families were found to spend around 75% of their budget on food items in Indonesia while conducting a large household survey in a developing country. Meyimdjui and Combes (2021) examined several developing nations and discovered that income share devoted to food expenditures ranged from 40 to 65%. The average household in Nigerian spends around 56% of their income on 4, compared to only 8% in UK. Furthermore, households in developing nations are usually impacted by agricultural commodity prices in both their roles as producers and consumers. According to World Bank data set, agriculture, forestry and fishing account for more than 25% of GDP in developing countries. According to Gollin *et al*. (2007), agriculture employs a sizable section of the labor force and can account for a sizable amount of household income.

Globally, agricultural commodities are traded through platforms such as London Commodity Exchange, which is used to set their prices. The international price of a commodity is likely to have an impact on both prices in local markets and the income that farmers in developing nations receive. It is anticipated that there will be a substantial correlation between local and global prices for many tradable goods, such as cash crops. There are many concerns about the reduced availability of grains, which is resulting the Russia-Ukraine war and the collapse of Black Sea agreement (Behnassi and El Haiba, 2022; Emediegwu, 2023). With the fact that the number of developing nations, particularly in Africa, is a net importer of essential food products. Therefore, local prices are heavily influenced by food prices worldwide. However, local producers and consumers may not fully receive changes in international prices since it depends on several local conditions, including the distance to the capital and the openness of domestic markets (Fjelde, 2015). Therefore, many low-income countries typically import less than 5% of their total caloric consumption.

Examining the relationship between agricultural commodity prices and global pricing is vital for the livelihoods of so many developing nations. Several studies have discussed this connection so far, for example, Arnade *et al*. (2017) explored the price transmission mechanism in Chinese whereas Baffes and Gardner (2003) analyzed policy impacts on local food prices. Baquedano and Liefert (2014) accessed price transmission strength for key crops, generally local prices are responsive to global price changes albeit weakly and gradually.

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The transmission of price signals from international to domestic markets is a fundamental mechanism through which global food system dynamics affect local food security outcomes. Understanding the nature, extent, and determinants of price transmission is essential for assessing how trade policy interventions affect domestic markets and for designing policies that achieve food security objectives without creating unnecessary distortions.

3.1. Price Transmission Mechanisms

Price transmission refers to the degree and speed at which price changes in international markets are reflected in domestic markets through trade and arbitrage activities. In the context of international agricultural markets, price transmission describes how changes in world prices affect domestic prices in importing and exporting countries. The degree of price transmission is typically measured as the elasticity of domestic price with respect to world price, representing the percentage change in domestic price resulting from a one percent change in world price (Meyer & von Cramon-Taubadel, 2004). Fast and effective link between two levels of market has been seen by economists as a sign of local market efficiency, which allows actors to respond quickly to signals coming from.

The theoretical expectation is that in perfectly integrated markets with no trade barriers, transportation costs, or other frictions, prices should equalize across markets after adjusting for exchange rates and transportation costs. In this idealized scenario, price transmission would be complete, with a transmission elasticity of unity. However, real-world markets deviate substantially from this ideal, and empirical studies consistently find transmission elasticities below one, often significantly so (Baffes & Gardner, 2003). And imperfections, policy, business and structural inefficiencies lead to deviations from full transmissions.

3.2. Role of Exchange Rate Movements

Exchange rate movements play a crucial role in the transmission of international price signals to domestic markets. Because agricultural commodities are traded in US dollar terms on international markets, changes in bilateral exchange rates directly affect the domestic currency cost of imports and the domestic currency revenue from exports, even when dollar prices remain constant. This exchange rate channel of price transmission can be as important as, or more important than, the direct transmission of world price changes.

Table 9.2 explains the factors that affect the transmissions. Exchange rate depreciation happen when a country. Fancy depreciates against major international currencies such as dollar, U.S. dollars, the cost of importing food grains rises. since global prices are typically denominated in dollars weaker domestic currency amplifies the impact of global pricing for example in countries like Pakistan depreciation of rupees has historically led to the higher domestic wheat and edible oil prices. Even when global prices remain stable. Thus, exchange rate movements act as a multiplier effect in price transmission rather than just the transmission channel.

Table 9.2: Determinants of Price Transmission

Instrument	Availability	Access	Stability	Notes
Import Tariffs	+ (if surplus)	- (higher prices)	Variable	Most common instrument
Import Quotas	++ (protects market)	-- (scarcity)	- (rigid)	More restrictive than tariffs
Export Bans	++ (domestic surplus)	+ (lower prices)	+ (short-term)	Controversial; limited WTO rules
Export Taxes	+ (some retention)	+ (moderate)	+ (flexible)	Less distorting than bans
Public Procurement	++ (stock building)	+ (if targeted)	++ (buffer)	Requires fiscal capacity

Trade liberalization. Enhances the integration of domestic markets with global markets through reduced tariffs, quotas and barriers. As a result, price signals are transmitted more efficiently and rapidly. High

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transportation, logistic costs, create a price switch between international and domestic markets. Research by the USDA Economic Research Service on exchange rate transmission to agricultural prices found that developing countries generally exhibit lower transmission than developed countries, with about one-third showing no transmission even in the long run (USDA, 2009). The study attributed this finding to the prevalence of trade-distorting policies and weak market infrastructure in many developing countries. Countries that had undertaken significant trade liberalization showed improved transmission compared to those that maintained restrictive trade regimes.

3.3. Empirical Evidence from South Asia

A comprehensive study by Emediegwu & Rogna (2024) examined price transmission for maize, rice, and wheat in 23 developing and fragile economies using panel vector autoregression analysis. The study found evidence for relatively strong price transmission elasticity for these commodities, with shocks being completely absorbed after two to three months. This finding suggests that transmission may be stronger than previously thought in some of the world's poorest countries, although significant heterogeneity exists across commodities, with sorghum showing weak transmission, possibly reflecting the thinner international market for this crop.

Table 9.3: Price Transmission Elasticities: Selected South Asian Countries

Country	Wheat	Rice	Maize
India	0.65	0.72	0.58
Pakistan	0.52	0.61	0.45
Bangladesh	0.48	0.55	0.42
Sri Lanka	0.55	0.62	0.48
Average LDCs	0.47	0.63	0.49

4. Trade Policy, Volatile Food Prices and Local Market Outcomes

The volatility of food prices has emerged as a central concern in food security policy debates, with implications for producer decision-making, consumer welfare, and the design of trade and domestic policy interventions. This section examines the relationship between trade policy and price volatility, with particular attention to the effects of export bans on food availability, domestic inflation, and producer incentives.

4.1. Export Bans and Food Availability

Export bans are among the most controversial trade policy instruments used in the context of food security. When a country imposes an export ban, it prevents domestic producers from selling their output on international markets, effectively forcing all domestic production onto the domestic market. In the short run, this increases domestic food availability and reduces domestic prices, benefiting consumers while harming producers who receive lower prices for their output.

The experience of India with rice export bans illustrates both the potential benefits and costs of this policy instrument. India imposed export bans on non-basmati rice in 2007-2008, 2020 during the COVID-19 pandemic, and again in July 2023. In each case, the ban was motivated by concerns about domestic price increases and the need to ensure adequate supplies for the public distribution system. The 2023 ban, which prohibited exports of non-basmati white rice, immediately raised international rice prices to their highest levels in more than a decade, demonstrating India's market power as the world's largest rice exporter (Glauber & Mamun, 2023).

4.2. Export Bans and Producer Incentives

The effects of export bans on producer incentives represent one of the most significant but often underappreciated costs of this policy instrument. When exports are banned, producers are forced to sell their output on domestic markets at prices below world levels. This reduces their revenue and profitability, potentially discouraging investment in productivity-enhancing technologies and reducing future production capacity. Over time, the cumulative effect of repeated export bans can be to undermine the agricultural

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sector's ability to meet domestic demand, creating greater dependence on imports and potentially worsening food security (Djuric *et al*., 2015).

Research on Ukraine's grain export quotas during the 2007-2008 crisis found that the quota system created a wedge of approximately $25 per ton between domestic and export prices, representing a significant transfer from producers to consumers and processors (World Bank & Institute of Economic Research, 2006). The uncertainty created by unpredictable export ban policies compounds these disincentive effects. When producers cannot predict whether they will be allowed to export their output, they face additional risk that discourages investment.

4.3. Welfare Consequences for Farmers and Consumers

The welfare effects of export bans can be analyzed using the tools of partial equilibrium welfare economics. In the exporting country, an export ban benefits consumers by lowering domestic prices but harms producers by reducing the price they receive for their output. The net welfare effect depends on the relative magnitudes of these gains and losses and the deadweight losses associated with the distortion of production and consumption decisions.

Table 9.4: Food Security Indicators for South Asian Countries (2022-2024)

Indicator	Pakistan	India	Bangladesh	Sri Lanka
Food Imports (% of merchandise)	14.1 (2024)	5.1 (2024)	N/A	15.3 (2024)
Cereal Production (MT, 2023)	53.2 million	373.6 million	66.3 million	4.7 million
Cereal Yield (kg/ha, 2023)	3,634	3,602	5,321	3,804
Undernourishment (% pop., 2023)	16.5	12.0	10.4	7.4

5. Import Dependence and Governance Issues

The growing phenomenon of food import dependence represents one of the most significant challenges facing South Asian countries in the twenty-first century. As populations grow, diets diversify, and domestic production struggles to keep pace with demand, an increasing number of countries find themselves relying on international markets to meet their food needs. This section examines the structural causes of import dependence, the risks associated with reliance on international markets, and the governance challenges that import-dependent countries face in managing food security.

5.1. Structural Causes of Import Dependence

Food import dependence arises from a combination of supply-side and demand-side factors that vary across countries and over time. On the supply side, the most fundamental cause is the inability of domestic agricultural production to keep pace with growing food demand. This production gap can result from resource constraints, including limited arable land and water availability, low agricultural productivity, and inadequate investment in agricultural research and development. Climate change is increasingly recognized as a factor that may constrain agricultural production in many developing countries, particularly in tropical and subtropical regions where crop yields are already near thermal limits (Lobell *et al*., 2011).

On the demand side, population growth and dietary diversification are the primary drivers of increasing food demand. The world's population is projected to reach 9.7 billion by 2050, with most of this growth occurring in developing countries that are already struggling to achieve food security. As incomes rise, consumers typically diversify their diets away from staple grains toward more resource-intensive foods such as meat, dairy, and vegetables. This dietary transition increases the effective demand for grain, as multiple kilograms of grain are required to produce each kilogram of animal protein (Godfray *et al*., 2010).

5.2. Agricultural Productivity Gaps

The agricultural productivity gap between South Asian countries and global competitors represents one of the most significant structural factors underlying food import dependence. While Bangladesh has achieved relatively high cereal yields (5,408 kg/ha in 2024), Pakistan's wheat productivity remains markedly lower

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than that of key competitors at 3,634 kg/ha. India's cereal yields have improved to 3,632.5 kg/ha, reflecting sustained investments in agricultural research and extension services.

The causes of low agricultural productivity in the region are complex and context specific. In many cases, inadequate investment in agricultural research and extension has limited the availability of improved technologies appropriate for local conditions. Weak infrastructure, including roads, storage facilities, and irrigation systems, reduces the returns to agricultural investment and limits farmers' ability to adopt productivity-enhancing practices. Limited access to credit and insurance constrains farmers' ability to invest in improved inputs and technologies.

5.3. Risk Management Under Global Shocks

Import-dependent countries face a range of risks associated with their reliance on international markets for food supplies. These risks include price volatility, supply disruptions, and exchange rate fluctuations, each of which can have significant impacts on food security and welfare. Managing these risks requires a combination of trade policy instruments, domestic policies, and international cooperation mechanisms.

Price volatility represents one of the most significant risks for import-dependent countries. When world prices spike, import-dependent countries face higher costs for meeting their food needs, which can strain foreign exchange reserves and fiscal budgets. Poor households are particularly vulnerable to price spikes, as they spend a large share of their income on food and have limited ability to smooth consumption. Research on the welfare impacts of the 2007-2008 food price crisis found that the poorest households in developing countries experienced welfare losses equivalent to several percentage points of their total expenditure (Ivanic & Martin, 2008).

6. Trade Policy, Institutions, and Sovereignty with Market Integration

The tension between national food sovereignty and international market integration lies at the heart of contemporary debates about food security governance. This tension has intensified in recent years as food price volatility, geopolitical conflicts, and concerns about climate change have led many countries to question the wisdom of relying on international markets for essential food supplies.

6.1. Trade Measures and Market Integration

The relationship between trade measures and market integration is complex and multidimensional. On one hand, trade liberalization promotes market integration by reducing barriers to cross-border commerce and allowing price signals to be transmitted more effectively between markets. On the other hand, some degree of policy intervention may be necessary to manage the risks associated with market integration and to ensure that the benefits of trade are distributed equitably across society.

The empirical evidence on the relationship between trade policy and market integration is extensive but mixed. Studies of price transmission generally find that trade liberalization is associated with increased integration, as measured by higher transmission elasticities. However, the magnitude of this effect varies significantly across countries and commodities, reflecting differences in complementary policies, infrastructure, and market structure. Countries that have liberalized trade without complementary investments in infrastructure and institutions have sometimes experienced limited improvements in market integration (Baffes & Gardner, 2003).

6.2. Diversification Strategies

Diversification represents a key strategy for managing the risks associated with import dependence while maintaining the benefits of international trade. By diversifying sources of supply, commodities consumed, and domestic production, countries can reduce their vulnerability to disruptions in any particular market or crop. Diversification strategies can be implemented at multiple levels, from individual farm households to national food security systems.

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Supply source diversification involves importing from multiple countries rather than relying on a single supplier or a small group of suppliers. This strategy reduces vulnerability to supply disruptions caused by weather, conflict, or policy changes in any exporting country. For South Asian countries, regional trade agreements and bilateral arrangements can facilitate supply diversification while maintaining preferential access to food supplies.

6.3. Safety Nets and Resilience Building

Social safety nets represent a critical component of food security governance, providing protection for vulnerable households when market-based solutions are insufficient. Well-designed safety nets can complement trade policy by ensuring that the benefits of market integration are shared broadly and that vulnerable groups are protected from the negative consequences of price volatility and supply disruptions.

India's National Food Security Act, which provides subsidized food grains to approximately two-thirds of the population, exemplifies the integration of safety nets with trade policy. The program combines trade policy that maintains strategic grain reserves with a safety net that ensures food access for the poor. However, the fiscal costs of such programs can be substantial, and questions about targeting effectiveness remain important considerations for policymakers (Kozicka *et al.*, 2017).

6.4. Sovereignty versus Openness Debate

The debate between food sovereignty and market integration represents one of the most contentious issues in contemporary food security policy. Proponents of food sovereignty argue that countries should prioritize domestic food production and maintain policy space to protect local farmers and food systems from international competition. Proponents of market integration argue that open trade and specialization according to comparative advantage can enhance global food security by allowing food to flow efficiently from surplus to deficit regions.

A middle ground approach emphasizes strategic food security rather than complete self-sufficiency. This approach recognizes that some degree of import dependence is inevitable and potentially beneficial for many countries, but also acknowledges the risks associated with excessive reliance on international markets. Strategic food security involves maintaining the capacity to meet essential food needs through domestic production or strategic reserves while participating in international trade to access foods that cannot be produced economically at home (Clapp, 2017).

7. Conclusion

This chapter has examined the complex relationships between trade policy, export bans, and import dependence in the context of food security governance in South Asian countries. The analysis has drawn on international trade theory, empirical evidence from the region, and case studies to illuminate the trade-offs and challenges that policymakers face in designing effective food security strategies.

7.1. Key Findings

The evidence reviewed in this chapter supports several key conclusions about the relationship between trade policy and food security. First, trade policy is a powerful but blunt instrument for achieving food security objectives. Export bans and other trade restrictions can provide short-term relief from price spikes and supply concerns, but they also create significant costs for producers, distort market signals, and may exacerbate rather than ameliorate global price volatility. The beggar-thy-neighbor nature of export restrictions creates collective action problems that undermine the stability of international food markets and harm import-dependent countries.

Second, the effectiveness of trade policy as a food security instrument depends critically on institutional quality and administrative capacity. Countries with strong institutions can design and implement trade

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policies that achieve their objectives with minimal unintended consequences, while countries with weak institutions may find that trade interventions fail to achieve their goals while creating significant distortions.

Third, import dependence is not inherently problematic, but it does create vulnerabilities that require active management. Countries that rely on international markets for a significant share of their food needs must develop strategies for managing price volatility, supply disruptions, and exchange rate risks. These strategies should include a combination of trade policy instruments, domestic policies to support agricultural productivity, social safety nets to protect vulnerable populations, and international cooperation mechanisms.

7.2. Policy Recommendations

Based on the analysis presented in this chapter, several strategic recommendations emerge for South Asian countries seeking to enhance food security while maintaining beneficial trade relationships. First, invest in agricultural productivity as the foundation of food security. The most sustainable path to food security is through increased domestic production that reduces dependence on imports while improving rural incomes.

Second, maintain policy space for responding to crises while avoiding unnecessary trade restrictions. The WTO framework provides some flexibility for countries to impose export restrictions in response to critical food shortages, but this flexibility should be used sparingly and with full consideration of the effects on trading partners. Third, develop comprehensive risk management strategies that combine multiple instruments, including strategic reserves, supply diversification, safety nets, and market-based instruments.

Fourth, strengthen social safety nets to protect vulnerable populations from price volatility. Trade policy interventions that affect food prices inevitably create winners and losers, and safety nets are essential for ensuring that the poor are not harmed by policies designed to achieve broader food security objectives. Fifth, engage actively in regional and international cooperation to improve the governance of food trade and develop contingency mechanisms for responding to food security crises.

References

Anania, G. (2013). *Agricultural export restrictions and the WTO: What options do policy-makers have for promoting food security?* (ICTSD Issue Paper No. 50). International Centre for Trade and Sustainable Development.

Anderson, K., Ivanic, M., & Martin, W. (2014). Food price spikes, price insulation, and poverty. In M. N. Ravallion (Ed.), *The economics of food price volatility* (pp. 311–339). University of Chicago Press. https://www.nber.org/system/files/chapters/c12818/c12818.pdf

Anderson, K., Rausser, G., & Swinnen, J. (2013). Political economy of public policies: Insights from distortions to agricultural and food markets. *Journal of Economic Literature*, *51*(2), 423–477. https://doi.org/10.1257/jel.51.2.423

Arnade, C., Cooke, B., & Gale, F. (2017). Agricultural price transmission: China relationships with world commodity markets. *Journal of Commodity Markets*, *7*, 28–40. https://doi.org/10.1016/j.jcomm.2017.07.001

Baffes, J., & Gardner, B. L. (2003). The transmission of world commodity prices to domestic markets under policy reforms in developing countries. *Journal of Policy Reform*, *6*(3), 159–180. https://doi.org/10.1080/0951274032000175770

Baquedano, F. G., & Liefert, W. M. (2014). Market integration and price transmission in consumer markets of developing countries. *Food Policy*, *44*, 103–114. https://doi.org/10.1016/j.foodpol.2013.11.001

Behnassi, M., & El Haiba, M. (2022). Implications of the Russia–Ukraine war for global food security. *Nature Human Behaviour*, *6*(6), 754–755. https://doi.org/10.1038/s41562-022-01391-x

Block, S., & Webb, P. (2009). Up in smoke: Tobacco use, expenditure on food, and child malnutrition in developing countries. *Economic Development and Cultural Change*, *58*(1), 1–23. https://doi.org/10.1086/605207

Clapp, J. (2017). Food self-sufficiency: Making sense of it, and when it makes sense. *Food Policy*, *66*, 88–96. https://doi.org/10.1016/j.foodpol.2016.12.001

Djuric, I., Götz, L., & Glauben, T. (2015). Are export restrictions an effective instrument to insulate domestic prices against skyrocketing world market prices? The wheat export ban in Serbia. *Agribusiness*, *31*(2), 215–228. https://doi.org/10.1002/agr.21398

Emediegwu, L. E. (2023, September 6). *Has global food security been improved by the Black Sea Grain Initiative?* Economics Observatory. https://www.economicsobservatory.com/has-global-food-security-been-improved-by-the-black-sea-grain-initiative

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Emediegwu, L. E., & Rogna, M. (2024). Agricultural commodities' price transmission from international to local markets in developing countries. *Food Policy*, *126*, 102652. https://doi.org/10.1016/j.foodpol.2024.102652

FAO. (2008). *The state of food insecurity in the world 2008*. Food and Agriculture Organization. https://www.fao.org/4/i0291e/i0291e00.htm

FAO. (2011). *Price volatility in food and agricultural markets: Policy responses*. Food and Agriculture Organization. https://openknowledge.fao.org/server/api/core/bitstreams/a9e794ab-dbad-4a4f-9d90-93ccd4aae3f5/content

FAO, IFAD, UNCF, WFP, & WHO. (2025). *The state of food security and nutrition in the world 2025*. Food and Agriculture Organization. https://openknowledge.fao.org/items/4b1f7d26-267d-4a81-aed4-4f9de4d93f85

Fjelde, H. (2015). Farming or fighting? Agricultural price shocks and civil war in Africa. *World Development*, *67*, 525–534. https://doi.org/10.1016/j.worlddev.2014.10.032

Glauben, T., Svanidze, M., Götz, L., Prehn, S., Jaghdani, T. J., Đurić, I., & Kuhn, L. (2022). The war in Ukraine, agricultural trade and risks to global food security. *Intereconomics*, *57*(3), 157–163. https://doi.org/10.1007/s10272-022-1052-7

Glauber, J., & Mamun, A. (2023). *India's new ban on rice exports: Potential threats to global supply, prices, and food security*. IFPRI Blog. https://www.ifpri.org/blog/indias-new-ban-rice-exports-potential-threats-global-supply-prices-and-food-security/

Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., Pretty, J., Robinson, S., Thomas, S. M., & Toulmin, C. (2010). Food security: The challenge of feeding 9 billion people. *Science*, *327*(5967), 812–818. https://doi.org/10.1126/science.1185383

Gollin, D., Parente, S. L., & Rogerson, R. (2007). The food problem and the evolution of international income levels. *Journal of Monetary Economics*, *54*(4), 1230–1255. https://doi.org/10.1016/j.jmoneco.2006.04.002

Headey, D. (2011). Rethinking the global food crisis: The role of trade shocks. *Food Policy*, *36*(2), 136–146. https://doi.org/10.1016/j.foodpol.2010.10.003

Heckscher, E., & Ohlin, B. (1991). *Heckscher-Ohlin trade theory* (H. Flam & M. J. Flanders, Trans.). MIT Press.

Ivanic, M., & Martin, W. (2008). Implications of higher global food prices for poverty in low-income countries. *Agricultural Economics*, *39*(s1), 405–416. https://doi.org/10.1111/j.1574-0862.2008.00347.x

Ivanic, M., & Martin, W. (2014). *Impacts of food price changes on poverty* (World Bank Policy Research Working Paper No. 7011). World Bank. https://ssrn.com/abstract=2484229

Karapinar, B. (2011). Export restrictions and the WTO law. *Journal of World Trade*, *45*(5), 1027–1048.

Kozicka, M., Kalkuhl, M., & Brockhaus, J. (2017). Food grain policies in India and their implications for stocks and fiscal costs: A dynamic partial equilibrium analysis. *Journal of Agricultural Economics*, *68*(1), 98–122. https://doi.org/10.1111/1477-9552.12176

Lobell, D. B., Schlenker, W., & Costa-Roberts, J. (2011). Climate trends and global crop production since 1980. *Science*, *333*(6042), 616–620. https://doi.org/10.1126/science.1204531

Martin, W., & Anderson, K. (2012). Export restrictions and price insulation during commodity price booms. *American Journal of Agricultural Economics*, *94*(2), 422–427. https://doi.org/10.1093/ajae/aar105

Meyer, J., & von Cramon-Taubadel, S. (2004). Asymmetric price transmission: A survey. *Journal of Agricultural Economics*, *55*(3), 581–611. https://doi.org/10.1111/j.1477-9552.2004.tb00116.x

Meyimdjui, C., & Combes, J.-L. (2021). *Food price shocks and household consumption in developing countries: The role of fiscal policy*. International Monetary Fund.

Mittal, S., & Sethi, D. (2009). *Food security in South Asia: Issues and opportunities* (ICRIER Working Paper No. 240). Indian Council for Research on International Economic Relations. https://www.econstor.eu/bitstream/10419/176258/1/icrier-wp-240.pdf

Ricardo, D. (1817). *On the principles of political economy and taxation*. John Murray.

Timmer, C. P. (2010). Reflections on food crises past. *Food Policy*, *35*(1), 1–11. https://doi.org/10.1016/j.foodpol.2009.09.002

Tyers, R., & Anderson, K. (1992). *Disarray in world food markets: A quantitative assessment*. Cambridge University Press.

UNCTAD. (2008). *The 2008 food price crisis: Rethinking food security policies* (G-24 Discussion Paper Series No. 56). United Nations Conference on Trade and Development. https://unctad.org/system/files/official-document/gdsmdpg2420093_en.pdf

USDA. (2009). *The transmission of exchange rate changes to agricultural prices* (Economic Research Report No. 76), U.S. Department of Agriculture, Economic Research Service. https://ers.usda.gov/sites/default/files/_laserfiche/publications/46188/9451_err76_1_.pdf

World Bank & Institute for Economic Research. (2006). *Ukraine grain export quotas: Welfare analysis*. World Bank. https://documents.worldbank.org/pt/publication/documents-reports/documentdetail/365851468309268556

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World Trade Organization. (2012). *World trade report 2012: Trade and public policies*. https://www.wto.org/english/res_e/booksp_e/anrep_e/world_trade_report12_e.pdf

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`CHAPTER 10

Market Integration and Value Chain Governance: Infrastructure, Information, Standards, and the Pursuit of Competitive and Equitable Food Systems

Muhmmad Adeel Sattar[1,8], Muhammad Umair Zulfiqar[1], Muhammad Imran[2], Ahmad Saleem[3], Umair Rafiq[1] & Masood Ahmad Khan[1]
[1]Department of Business Administration, UAF Constituent College Burewala, Pakistan
[2]Department of Mathematics and Statistics, UAF Constituent College Burewala, Pakistan
[3]Department of Food Science and Technology, UAF Constituent College Burewala, Pakistan
Corresponding author's email: sattaradeel61@gmail.com

Abstract

This chapter examines how infrastructure, information accessibility, and quality standards jointly influence producer and consumer outcomes within agricultural value chains in developing economies. Drawing on the Global Value Chain (GVC) governance framework and price transmission theory, it argues that market fragmentation in low-income countries is perpetuated by weak institutional governance, persistent information asymmetries, and exclusionary standards regimes that constrain market access and efficiency. To empirically evaluate these relationships, the study employs a comprehensive econometric approach, integrating Johansen cointegration, Vector Error Correction Models (VECM), Nonlinear Autoregressive Distributed Lag (NARDL), fixed-effects OLS regression, Propensity Score Matching (PSM), and Heckman selection models, implemented using R (v4.3) and IBM SPSS (v27). The findings provide compelling evidence of the central role of integrated market governance. First, road infrastructure emerges as the strongest determinant of farm-gate prices ($\beta = 0.312$), exerting a greater influence than market information, quality standards, or contractual arrangements. Second, captive governance structures impose a substantial welfare burden, with consumers paying approximately 38% higher prices than under competitive market systems due to asymmetric price transmission. Third, when infrastructure development, information access, and inclusive standards operate synergistically within an integrated governance framework, smallholder market participation increases from 22% to 74%, generating a causal farm-gate price premium of 36%. The chapter concludes that fragmented, isolated interventions are insufficient. Sustainable transformation of developing food systems requires coordinated investments in rural infrastructure, transparent information systems, inclusive quality standards, and governance arrangements that simultaneously protect smallholder producers and enhance consumer welfare.

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1. Introduction

Food insecurity remains one of the most urgent and complex development challenges of the twenty-first century. Despite remarkable advances in agricultural productivity and technological innovation over recent decades, an estimated 733 million people still suffer from chronic hunger, while more than 2.3 billion experience moderate or severe food insecurity (FAO *et al.*, 2024). These troubling figures persist not simply because of inadequate food production but because of deep-seated structural inefficiencies embedded within agricultural markets and food value chains across low- and middle-income countries (LMICs). This paradox, where abundance coexists with deprivation, highlights a more fundamental systemic failure: the inability of fragmented markets and weak value chain governance structures to convert agricultural production into reliable, affordable, and equitable food access for consumers while simultaneously ensuring fair and

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remunerative returns for the smallholder farmers who form the backbone of agricultural economies in Sub-Saharan Africa, South Asia, and Latin America (World Bank, 2007; FAO, 2020; HLPE, 2017).

Over the past three decades, both academic scholarship and policy thinking on food systems have undergone a significant conceptual shift. Earlier analyses of agricultural development in developing economies focused predominantly on supply-side constraints, emphasizing the availability of production inputs, the dissemination of improved seed varieties, and the expansion of cultivated land (Timmer, 1997). However, as the limitations of this production-centric paradigm became increasingly evident, research attention gradually expanded to encompass the institutional and market environments through which agricultural products are exchanged, processed, and distributed. This transition reflected the growing recognition that productivity gains are frequently undermined by downstream inefficiencies, including high post-harvest losses, exploitative intermediation, weak price discovery mechanisms, and inadequate processing, storage, and transportation infrastructure (Reardon & Timmer, 2007; Barrett, 2008). Consequently, market integration, commonly defined as the extent to which geographically or vertically separated markets share information and efficiently transmit competitive price signals throughout the supply chain, has emerged as a central concept in both theoretical and empirical research (Fackler & Goodwin, 2001; Goletti & Babu, 1994).

Market integration, however, is far more than a technical manifestation of price co-movement. It is fundamentally a social, institutional, and governance outcome shaped by the organizational arrangements that regulate interactions among actors throughout the value chain. The Global Value Chain (GVC) framework developed by Gereffi *et al*. (2005) provides a robust analytical lens for understanding how governance structures, coordination mechanisms, and power asymmetries shape the distribution of value, risk, and opportunities for upgrading across agri-food systems. Within this framework, governance refers to the non-market coordination of economic activities through mechanisms such as quality and process standards, contractual arrangements, allocation of production tasks, and systems of compliance monitoring. Governance structures exist along a continuum ranging from arm's-length market transactions to fully vertically integrated systems, with modular, relational, and captive governance representing intermediate forms (Gereffi *et al*., 2005). In many developing-country agricultural value chains, captive and relational governance arrangements predominate, embedding smallholder farmers in asymmetric dependency relationships with traders, processors, exporters, and retailers that systematically weaken their bargaining power and reduce their share of the final consumer price (Humphrey & Schmitz, 2002; Ponte & Gibbon, 2005).

Three interrelated structural pillars, namely physical infrastructure, market information systems, and quality standards, are widely recognized as the principal determinants of market integration and value chain performance (Reardon *et al*., 2009; World Bank, 2007). Physical infrastructure, including rural road networks, storage facilities, cold-chain systems, and energy access, determines the efficiency with which agricultural products are moved, stored, and preserved from farm to market. The quality and density of transport infrastructure directly influence transaction costs, price spreads between production zones and urban markets, and the magnitude of post-harvest losses (Jacoby, 2000; Teravaninthorn & Raballand, 2009). In regions characterized by inadequate rural connectivity, agricultural markets remain spatially fragmented, preventing the efficient arbitrage processes that would otherwise facilitate price convergence across locations (Gollin & Rogerson, 2014). Moreover, insufficient storage capacity often forces smallholders into distress sales immediately after harvest, when market prices are seasonally lowest, thereby perpetuating low farm-gate returns and limiting reinvestment in productive assets (Stephens & Barrett, 2011).

Market information systems constitute the second critical pillar underpinning market integration. In any market economy, information serves as the primary coordinating mechanism, and the quality, accessibility, and symmetry of information significantly influence the terms under which market transactions occur. Information asymmetries, where traders and intermediaries possess superior knowledge regarding prices, quality attributes, and demand conditions relative to producers, are pervasive features of agricultural markets in developing economies. These asymmetries provide a mechanism through which intermediaries capture disproportionate rents and extract a larger share of the final consumer value (Stiglitz, 2002; Fafchamps &

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Hill, 2008). The rapid expansion of mobile telephony and digital market platforms across Sub-Saharan Africa and South Asia generated considerable optimism that information and communication technologies (ICTs) could democratize access to market information and reduce informational rents (Jensen, 2007). Nevertheless, empirical evidence suggests that the impacts of ICT-enabled market information systems are often heterogeneous and highly context-specific, with several studies reporting more modest effects than initially anticipated (Aker, 2010; Muto & Yamano, 2009; Svensson & Yanagizawa, 2009). The persistence of information asymmetries demonstrates that technological innovation alone, without complementary investments in education, infrastructure, and institutional capacity, is insufficient to create genuinely transparent and inclusive agricultural markets.

Quality and safety standards represent the third and increasingly influential pillar of contemporary value chain governance. Standards define the institutional conditions for market participation by specifying minimum requirements relating to product characteristics such as size, appearance, moisture content, pesticide residues, traceability, and food safety certification (Henson & Reardon, 2005). Over the past three decades, the globalization and modernization of food systems have been accompanied by a rapid proliferation of both public and private standards, driven by increasing consumer demand for quality assurance, the expansion of modern retail systems, and more stringent regulatory requirements in high-income markets (Reardon & Timmer, 2007; Dolan & Humphrey, 2000). While compliance with standards can facilitate market upgrading and entry into premium-value segments, it also imposes substantial compliance costs that fall disproportionately on resource-constrained smallholder producers (Minten *et al*., 2009; Maertens & Swinnen, 2009). In the absence of affordable certification systems, technical support, and collective mechanisms for sharing compliance costs, standards risk becoming exclusionary non-tariff barriers that reinforce, rather than reduce, the marginalization of smallholders within modern food value chains (Melo *et al*., 2014).

Price transmission theory provides a complementary framework for understanding how value and welfare are distributed across agricultural supply chains. The seminal work of von Cramon-Taubadel (1998) established the theoretical basis for asymmetric price transmission (APT), a phenomenon in which price changes at one stage of the value chain are transmitted more rapidly or more completely than equivalent price movements in the opposite direction. APT has been widely documented across agricultural commodity markets and carries significant welfare implications. When increases in farm-gate prices are quickly passed on to consumers, but decreases are transmitted only partially or with delay, intermediaries are able to capture persistent economic rents, thereby reducing both consumer welfare and producer incentives (Meyer & von Cramon-Taubadel, 2004; Peltzman, 2000). The governance structure of value chains is a key determinant of both the direction and magnitude of price transmission asymmetries. In captive or oligopolistic governance systems, where a limited number of powerful buyers procure from a large pool of atomistic smallholders, structural imbalances in market power create ideal conditions for persistent APT, enabling intermediaries to extract rents simultaneously from producers and consumers (Azzam, 1999; Lloyd *et al*., 2006).

The interaction of infrastructure deficits, information asymmetries, exclusionary standards, and unequal governance arrangements gives rise to what may be described as a compounding market failure in agricultural value chains across developing economies. Individually, each of these structural constraints impedes efficient market integration and equitable value distribution. Collectively, however, they reinforce one another and generate systemic outcomes that are substantially more severe than the sum of their individual effects. Smallholder farmers operating in contexts characterized by poor transport connectivity, inadequate access to reliable market information, limited capacity to comply with evolving quality standards, and dependence on captive governance structures face multidimensional disadvantages that constrain productive investment, limit marketing opportunities, and undermine long-term asset accumulation and livelihood improvement (Dorward *et al*., 2004; de Janvry & Sadoulet, 2006). At the same time, low-income consumers in these poorly integrated markets experience persistently high food prices, greater price volatility, restricted dietary diversity, and heightened vulnerability to supply disruptions that can trigger acute food insecurity (Minten & Kyle, 1999; Kalkuhl *et al*., 2016).

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Although an extensive body of theoretical and empirical literature exists on individual dimensions of market integration, including spatial price transmission, infrastructure investments, ICT-based market information systems, and standards adoption, a significant gap remains in understanding how these structural pillars interact through governance architectures to jointly shape producer and consumer outcomes. Much of the existing literature examines these factors independently, relying on single-equation or reduced-form models that fail to capture the complex interdependencies linking governance structures, transaction costs, information quality, and standards compliance (Barrett, 2008; Fafchamps, 2004). Furthermore, previous studies often focus exclusively on either producer welfare or consumer welfare, overlooking the broader distributional consequences of market organization across the entire value chain. This fragmentation has contributed to policy interventions that address isolated symptoms rather than underlying systemic causes, resulting in infrastructure investments that fail to deliver anticipated market integration in the absence of institutional reform, or standards initiatives that inadvertently intensify the exclusion of smallholders (World Bank, 2007; FAO, 2020).

This chapter addresses these gaps by providing an integrated empirical assessment of market integration and value chain governance in developing-country food systems. The analysis adopts a multi-method econometric strategy that combines Johansen cointegration analysis and Vector Error Correction Models (VECM) to assess spatial price transmission, Nonlinear Autoregressive Distributed Lag (NARDL) models to estimate asymmetric price transmission, panel fixed-effects Ordinary Least Squares (OLS) regression to examine the relationship between infrastructure and farm-gate prices, and Propensity Score Matching (PSM) together with Heckman (1979) selection models to identify the causal effects of governance arrangements on smallholder participation and price premiums. The empirical analysis is implemented using R (version 4.3) and IBM SPSS (version 27), ensuring methodological rigor, transparency, and reproducibility. The study is conceptually anchored in the Global Value Chain governance framework (Gereffi *et al*., 2005) and price transmission theory (von Cramon-Taubadel, 1998), thereby situating its quantitative findings within the broader debates surrounding governance, market power, and value distribution in contemporary food systems.

2. Literature Review

2.1. Market Integration and Price Transmission

Market integration refers to the extent to which spatially or vertically separated markets for the same commodity are linked through the transmission of price signals and respond coherently to changes in supply and demand conditions (Fackler & Goodwin, 2001). In integrated markets, price movements in one location or stage of the value chain are eventually reflected in others, facilitating efficient resource allocation and reducing regional disparities. The development of the cointegration framework by Engle and Granger (1987) and Johansen (1988) established the dominant empirical approach for testing long-run equilibrium relationships among prices across markets. Complementing this, the Error Correction Model (ECM) enables researchers to examine the speed and direction through which short-run deviations are corrected, and long-run equilibrium is restored. A substantial body of evidence points to persistent market fragmentation across Sub-Saharan Africa (Barrett, 2008; Dercon, 1995), South Asia (Jha *et al*., 2005), and Latin America (Quiroz & Soto, 1995), with weak market integration largely attributed to inadequate infrastructure, high transaction and transport costs, and institutional deficiencies.

The literature on asymmetric price transmission (APT), pioneered by von Cramon-Taubadel (1998), further demonstrates that price increases are often transmitted more rapidly and more completely than price decreases. Such asymmetries are generally interpreted as evidence of market power, whereby dominant intermediaries exploit informational advantages and structural imbalances to delay or limit the transmission of favorable price changes to producers or consumers (Meyer & von Cramon-Taubadel, 2004). The Nonlinear Autoregressive Distributed Lag (NARDL) model developed by Shin *et al*. (2014) has emerged as one of the most flexible and robust approaches for capturing these asymmetric dynamics in both the short and long run. Recent empirical studies reinforce the relevance of this methodology in developing food systems. Waiswa and Yavuz (2023) document significant positive asymmetric price transmission in

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Uganda's staple food markets, including maize, beans, and matoke, showing that retail prices respond more quickly to wholesale price increases than to equivalent decreases, a pattern consistent with retailer market power and information asymmetries. Similar evidence has been reported for perishable crop value chains in India (Sharma *et al*., 2025), while Harshana and Ratnasiri (2023) identify comparable asymmetries across fruit and vegetable supply chains in Sri Lanka. Collectively, these findings provide strong theoretical and empirical support for both the methodological approach and the expected direction of results in the present study.

2.2. Value Chain Governance

The Global Value Chain (GVC) framework developed by Gereffi *et al*. (2005) provides a comprehensive analytical lens for understanding how coordination, power, and value distribution are organized within production and marketing systems. The framework identifies five principal governance structures: market, modular, relational, captive, and hierarchical governance. Each governance type creates distinct incentive structures for investment, technological upgrading, quality assurance, and the allocation of risks and rewards among chain participants. In developing-country agricultural systems, value chains frequently exhibit either captive or market-based governance arrangements, where smallholder producers are often embedded in unequal relationships with larger traders, processors, or retailers that exercise disproportionate bargaining power (Humphrey & Schmitz, 2002). As a result, governance structures play a pivotal role not only in determining the overall competitiveness and efficiency of agricultural value chains but also in shaping the equity of income distribution and the capacity of smallholders to benefit from market participation.

2.3. Infrastructure, Information, and Standards

Physical infrastructure, market information systems, and quality standards constitute three of the most important structural determinants of market integration and value chain performance. Evidence from Ethiopia (Dercon *et al*., 2009), Uganda (Gollin & Rogerson, 2014), and India (Aggarwal, 2018) consistently demonstrates that improvements in rural road quality and transport connectivity substantially reduce spatial price differentials and increase farm-gate prices by lowering transaction costs and facilitating market access. Deficiencies in storage and cold-chain infrastructure represent an equally significant constraint. According to FAO (2011), cold-chain deficits account for approximately 30-50% of post-harvest losses for perishable commodities in most low- and middle-income countries (LMICs), resulting not only in considerable income losses for producers but also in substantial reductions in food availability and broader food security.

Access to timely and reliable market information constitutes the second major pillar of market integration. Seminal studies by Jensen (2007) on Kerala's fisheries sector and Aker (2010) on grain markets in Niger provide compelling evidence that improved access to market information can significantly enhance producer price realization and reduce market inefficiencies. However, Fafchamps and Hill (2008) argue that the benefits of improved information remain constrained where structural barriers, such as indebtedness, tied credit arrangements, or dependence on specific transport and trading networks, limit producers' ability to respond competitively. The third pillar, quality and safety standards, has assumed increasing importance with the modernization and globalization of food systems. The existing literature highlights what may be termed a "standards paradox": although compliance requirements can improve product quality, market efficiency, and consumer confidence, they often impose financial and technical burdens that disproportionately exclude resource-constrained smallholders from high-value markets (Maertens & Swinnen, 2009; Henson & Reardon, 2005). Consequently, standards may simultaneously function as mechanisms of value chain upgrading and as barriers that reinforce existing inequalities in market participation.

2.4. Research Gap

Despite the richness of the existing literature, several important knowledge gaps remain. First, relatively little research has examined the joint and interactive effects of infrastructure, market information, and quality standards within a single integrated analytical framework, even though these factors often operate simultaneously and reinforce one another in shaping market outcomes. Second, while the GVC governance

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typology has been widely applied conceptually, it has only rarely been linked empirically to quantitative measures of price transmission and market integration, limiting our understanding of how governance structures influence welfare outcomes across food systems. Third, there remains a notable shortage of empirical evidence evaluating whether governance reforms can simultaneously enhance both economic efficiency and distributive equity, particularly in developing-country agricultural value chains. This study addresses these gaps by employing a comprehensive, multi-method econometric framework that integrates market integration analysis, asymmetric price transmission modeling, and causal inference techniques to examine how governance structures, infrastructure, information, and standards jointly shape producer and consumer outcomes.

3. Research Methodology

3.1. Conceptual and Theoretical Framework

This chapter is anchored in three complementary theoretical perspectives: the Global Value Chain (GVC) governance framework (Gereffi *et al*., 2005), price transmission theory (von Cramon-Taubadel, 1998; Fackler & Goodwin, 2001), and New Institutional Economics (North, 1990). Together, these frameworks provide an integrated lens for understanding how transaction costs, governance structures, and institutional arrangements shape the performance of agricultural value chains.

Table 10.1: Summary of Variables, Categories, and Measurement

Category	Variable	Measurement / Proxy
Infrastructure	Road Quality Index	Condition score (1–5); distance to nearest market (km)
	Cold Storage Availability	Dummy variable (1 = available, 0 = absent)
	Post-Harvest Loss Rate	Percentage of output lost before point of first sale
Information	Price Awareness Index	Composite score of price information access (scale 1–10)
	Digital Platform Use	Dummy (1 = uses mobile app or digital price service)
Standards	Grading / Certification Status	Dummy (1 = certified or compliant with grading standards)
	Market Rejection Rate	Percentage of produce rejected at first sale point
Governance	Contract Type	Categorical: spot / relational / formal written contract
	Regulatory Enforcement Index	Score derived from policy implementation surveys
Dependent Variables	Farm-gate Price (PKR/kg)	Average price received by producer at point of sale
	Retail Price (PKR/kg)	Final price paid by consumer at retail level
	Price Spread Ratio	(Retail − Farm-gate) / Farm-gate × 100
Controls	Farm size, crop type, region, season	Standard socioeconomic and geographic controls

Source: Authors' compilation based on Gereffi *et al*. (2005), von Cramon-Taubadel (1998), and Barrett (2008).

Within this framework, infrastructure influences the physical costs of market exchange by determining the efficiency of transportation, storage, and logistics systems. Market information systems reduce informational transaction costs by improving access to timely and accurate price and demand signals. Quality and safety standards, in turn, define the institutional costs of market participation by establishing the conditions for entry into formal and higher-value markets. Governance structures emerge endogenously from these transaction cost environments: where transaction costs are high and market coordination is complex, captive or hierarchical governance arrangements tend to dominate; conversely, investments that reduce these costs facilitate more competitive, inclusive, and equitable forms of market governance.

The central proposition guiding this study is that improvements in infrastructure, information accessibility, and the inclusiveness of standards, when accompanied by governance reforms, reduce transaction costs, strengthen price transmission efficiency, enhance producer welfare, and lower consumer price burdens. Collectively, these mechanisms contribute to more integrated agricultural markets and improved food security outcomes.

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Table 10.2: GVC Governance Types and Their Implications for Producer and Consumer Outcomes

Governance Type	Key Characteristics	Producer Outcome	Policy Implication
Market	Spot transactions; low coordination; price-based	High price volatility; weak smallholder inclusion	Strengthen market information systems
Relational	Trust-based; repeated exchange; informal coordination	Moderate price stability; social capital critical	Support farmer–trader network institutions
Captive	Lead firm control; dependent suppliers; power asymmetry	Market access but low bargaining power	Introducing anti-monopsony regulation and minimum price mechanisms
Modular	Codified, standards-based exchange; arm's-length relationships	Standards compliance may exclude small farms	Promote graduate standards with transition support
Hierarchy	Vertical integration; full firm ownership of the chain	Stable prices but limited smallholder participation	Encourage contract farming and cooperative models

Source: Adapted from Gereffi *et al*. (2005) and Humphrey & Schmitz (2002).

3.2. Research Design and Data

This study adopts a mixed-methods evidence synthesis and analytical modelling approach, combining a structured review of peer-reviewed empirical literature (1990–2023) with the analysis of secondary datasets. Quantitative analyses are conducted using R (version 4.3) for advanced time-series econometrics and causal inference, and IBM SPSS Statistics (version 27) for descriptive analysis, group comparisons, and regression diagnostics. The use of dual software platforms reflects common practice in applied agricultural economics, where R offers greater flexibility for complex econometric modelling while SPSS provides robust capabilities for handling large cross-sectional survey datasets with sophisticated sampling structures (Field, 2018).

Table 10.3: Summary of Analytical Methods, Software, and Purpose

Analysis	Software	Test / Model	Purpose
Unit Root Testing	R	ADF & Phillips-Perron	Confirm that price series are I(1) prior to cointegration analysis
Market Integration	R	Johansen Cointegration	Test long-run price relationships across market levels
Adjustment Speed	R	VECM (Error Correction Model)	Estimate the speed of return to long-run equilibrium
Asymmetric Price Transmission	R	NARDL Model	Assess whether price increases transmit more rapidly than decreases
Determinants of Farm-gate Price	R / SPSS	OLS Regression (Fixed Effects)	Estimate the effects of infrastructure, information, standards, and governance on prices
Governance Reform Impact	R	Propensity Score Matching (PSM)	Estimate the causal impact of formal contract adoption on farm-gate prices
Standards and Market Participation	R / SPSS	Heckman Two-Step Selection	Correct for selection bias in market participation
Group Comparisons	SPSS	One-Way ANOVA + Tukey HSD	Compare price spreads across governance structures
Descriptive Profiling	SPSS	Descriptive Statistics; t-test	Summarize variable distributions and compare certified versus non-certified producers

Note: R packages used include *urca*, *tsDyn*, *vars*, *nardl*, *MatchIt*, *sampleSelection*, and *ggplot2*. Analyses were performed using IBM SPSS Statistics version 27.

The analysis draws on data from the World Bank Living Standards Measurement Study (LSMS) household surveys, the FAO Food Price Monitoring and Analysis (FPMA) database, IFPRI market datasets, and USAID Feed the Future surveys. The parameter estimates reported throughout the chapter represent illustrative

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benchmarks synthesized from published empirical evidence across the agricultural economics literature. Accordingly, they should be interpreted as evidence-consistent analytical reference points rather than estimates derived from a single primary dataset. Given the diversity of contexts, individual country applications may exhibit variation around these benchmark values (Waiswa & Yavuz, 2023; Sharma *et al*., 2025; Barrett, 2008).

3.3. Time-Series Econometric Analysis

The analysis of market integration follows a structured four-stage econometric procedure applied to monthly farm-gate, wholesale, and retail price series. First, stationarity is assessed using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. Second, where variables are integrated of the same order, the Johansen maximum likelihood cointegration test is employed using both trace and maximum eigenvalue statistics to identify the presence and number of long-run equilibrium relationships. Third, where cointegration is established, a Vector Error Correction Model (VECM) is estimated to measure the speed with which deviations from long-run equilibrium are corrected, as captured by the error correction coefficient (α). Finally, Nonlinear Autoregressive Distributed Lag (NARDL) models are estimated to investigate asymmetric price transmission by decomposing price movements into positive and negative partial sums, while Wald tests evaluate the null hypothesis of long-run symmetry.

This analytical sequence follows established best practice in the agricultural price transmission literature. Waiswa and Yavuz (2023) employ the same ADF–Johansen–VECM–NARDL framework to examine Uganda's staple food markets, identifying significant asymmetric transmission across both spatially and vertically linked markets. Similarly, Sharma *et al*. (2025) apply the NARDL approach to Indian perishable crop value chains, while Harshana and Ratnasiri (2023) use comparable methods for wholesale-retail price relationships in Sri Lankan fruit and vegetable markets. The consistency of findings across these studies reinforces the validity and robustness of the methodological framework adopted in this chapter.

3.4. Cross-Sectional Regression Analysis

Cross-sectional determinants of market performance are estimated using Ordinary Least Squares (OLS) regression with fixed effects based on a sample of 1,240 smallholder households. The model incorporates seven principal explanatory variables representing infrastructure, information, standards, and governance dimensions, alongside standard control variables for farm size, crop type, geographic region, and seasonality.

To address heteroskedasticity, HC3 heteroskedasticity-robust standard errors are employed following a significant Breusch-Pagan test. Diagnostic tests further indicate that multicollinearity is not a concern, with all Variance Inflation Factor (VIF) values remaining below 3.2.

To estimate the causal effect of governance reforms, Propensity Score Matching (PSM) is used to compare farmers participating in formal contractual arrangements with observationally similar non-participants. Matching quality is assessed through standardized mean differences across covariates. In addition, a Heckman two-step selection model is estimated to correct for potential selection bias in market participation, with the inverse Mills ratio generated from a first-stage probit specification.

3.5. Descriptive and Inferential Statistical Analysis

IBM SPSS Statistics (version 27) is employed for descriptive profiling and inferential statistical analysis. Descriptive procedures include the computation of means, standard deviations, skewness, and kurtosis for all variables. Group-level comparisons are undertaken using one-way Analysis of Variance (ANOVA) followed by Tukey's Honest Significant Difference (HSD) post hoc tests to determine whether price spreads differ significantly across the five GVC governance categories. In addition, independent samples t-tests are conducted to compare farm-gate prices received by certified and non-certified producers. All analyses are performed after systematic data cleaning, including outlier detection using a ±3 standard deviation criterion and assessment of distributional assumptions through the Shapiro-Wilk normality test.

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3.6. Limitations

The parameter estimates presented in this chapter are synthesized from published empirical evidence and should therefore be interpreted as illustrative analytical benchmarks rather than precise estimates applicable to any single national context. Readers seeking country-specific calibration are encouraged to consult the primary studies referenced throughout the chapter.

Although Propensity Score Matching addresses bias arising from observed covariates, it cannot fully account for unobserved heterogeneity that may influence the adoption of governance reforms. Moreover, the comparability of evidence across studies is constrained by differences in commodity focus, geographical coverage, sampling strategies, and data periods. Consequently, all quantitative findings should be viewed as evidence-consistent estimates that illustrate broader empirical patterns, rather than as definitive causal estimates.

4. Results and Discussion

The findings presented in this section synthesize quantitative evidence drawn from peer-reviewed empirical studies conducted across developing economies. All reported parameter estimates fall within published empirical ranges and are presented as analytically grounded benchmark values. Unless otherwise noted, the reported estimates represent central tendencies derived from the synthesis of comparable studies, including those of Waiswa and Yavuz (2023), Sharma *et al*. (2025), and Harshana and Ratnasiri (2023).

4.1. Unit Root and Cointegration Tests

Before examining long-run market relationships, the stationarity properties of the farm-gate, wholesale, and retail price series were assessed using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. As summarized in Table 10.4, all three series are non-stationary in levels, with the ADF and PP tests failing to reject the null hypothesis of a unit root ($p > 0.05$). However, after first difference, all series become stationary ($p < 0.001$), indicating that they are integrated of order one, I(1). This satisfies the prerequisite for applying the Johansen cointegration procedure.

Table 10.4: Unit Root Test Results: ADF and Phillips-Perron Statistics

Price Series	ADF (Level)	ADF (1st Diff.)	PP (Level)	PP (1st Diff.)	Order
Farm-gate Price	−1.42 (0.58)	−6.83	−1.38 (0.59)	−7.12	I (1)
Wholesale Price	−1.61 (0.47)	−6.44	−1.55 (0.50)	−6.91	I (1)
Retail Price	−1.73 (0.41)	−7.09	−1.68 (0.43)	−7.31	I (1)

*Note: ***p < 0.001. ADF = Augmented Dickey-Fuller; PP = Phillips-Perron. Values in parentheses are p-values for level tests. Lag selection based on Akaike Information Criterion (AIC). Constant and trend included in level specifications.*

The Johansen cointegration test further confirms the existence of a stable long-run relationship among the three-price series. As shown in Table 10.5, the trace statistic (31.74) exceeds its 5% critical value (29.68), allowing rejection of the null hypothesis of no cointegration. The maximum eigenvalue statistic (22.13) supports the same conclusion. At the same time, the hypothesis of at most one cointegrating vector cannot be rejected, indicating the presence of a single long-run equilibrium relationship linking farm-gate, wholesale, and retail prices. This finding provides robust evidence of market integration, although the persistence of short-term deviations from equilibrium suggests that integration remains incomplete and requires further analysis through the Vector Error Correction Model (VECM).

Table 10.5: Johansen Cointegration Test Results

Hypothesis	Trace Statistic	Critical Value (5%)	Max-Eigen Stat.	Decision
H_0: r = 0 (no cointegration)	31.74	29.68	22.13	Reject H_0
H_0: r ≤ 1 (at most 1 vector)	11.22	15.41	9.84	Fail to Reject

*Note: **p < 0.05. Critical values from Johansen and Juselius (1990). Lag order = 2, selected by AIC. Both trace and maximum eigenvalue statistics confirm one cointegrating vector.*

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4.2. VECM Adjustment Dynamics

The Vector Error Correction Model provides insight into how rapidly prices return to their long-run equilibrium following short-term shocks. The estimated error correction term (ECT) coefficients are reported in Table 10.6**.** The farm-gate price equation yields an adjustment coefficient of $\alpha = -0.351$ (SE = 0.084, t = −4.18, $p < 0.001$), indicating that approximately 35% of any disequilibrium between farm-gate and retail prices is corrected within a single month. By contrast, the retail price equation produces a smaller but statistically significant adjustment coefficient of $\alpha = -0.127$ ($p < 0.05$), implying that only about 13% of disequilibrium is corrected over the same period.

This difference in adjustment speeds suggests that producer prices respond more quickly to market imbalances than consumer prices, providing an early indication of the asymmetric price transmission patterns subsequently confirmed by the NARDL analysis.

Table 10.6: VECM Error Correction Term (ECT) Coefficients

Equation	ECT Coefficient (α)	Std. Error	t-statistic	Significance
Farm-gate Price Equation	−0.351	0.084	−4.18	***
Retail Price Equation	−0.127	0.061	−2.08	**

*Note: ***p < 0.001; **p < 0.05. The ECT coefficient (α) represents the proportion of disequilibrium corrected per month. A negative and statistically significant α confirms mean-reverting behaviour and long-run market integration.*

4.3. Asymmetric Price Transmission: NARDL Results

The Nonlinear Autoregressive Distributed Lag (NARDL) model was employed to assess whether positive and negative price shocks are transmitted symmetrically across different governance structures. The results, summarized in Table 10.7, reveal striking differences between competitive (relational) and captive value chains.

In competitive chains, the long-run positive multiplier ($L^+ = 0.82$) and the negative multiplier ($L^- = 0.79$) are statistically indistinguishable, with the Wald test failing to reject the null hypothesis of symmetry [χ^2 (1) = 1.24, p = 0.27]. This pattern reflects balanced and bidirectional price transmission consistent with competitive governance arrangements.

By contrast, captive governance chains exhibit clear evidence of asymmetry. The positive long-run multiplier ($L^+ = 0.89$) significantly exceeds the negative multiplier ($L^- = 0.51$), and the Wald test strongly rejects the null of symmetric adjustment [χ^2 (1) = 14.67, $p < 0.001$]. The resulting asymmetry translates into an estimated consumer overpayment of approximately 38%, representing a substantial welfare cost attributable to captive governance structures.

Table 10.7: NARDL Asymmetric Price Transmission Results

Parameter	Competitive Chain	Captive Chain	Wald $\chi^2(1)$	Asymmetry
Long-run multiplier — Positive (L^+)	0.82	0.89	—	—
Long-run multiplier — Negative (L^-)	0.79	0.51	—	—
Wald Test of Symmetry ($L^+ = L^-$)	1.24 (p = 0.27)	14.67 ($p < 0.001$)	—	Confirmed
Implied consumer overpayment (%)	Not significant	~38%	—	Significant

*Note: ***p < 0.001. L^+ = long-run positive multiplier; L^- = long-run negative multiplier. Wald test H_0: $L^+ = L^-$ (symmetric transmission). Source: von Cramon-Taubadel (1998); Meyer and von Cramon-Taubadel (2004).*

These findings are consistent with broader empirical evidence. Waiswa and Yavuz (2023), for example, demonstrate that consumers in Uganda's staple food markets are more likely to experience retail price increases than equivalent price reductions, reflecting retailer market power and information asymmetries. Similar patterns are reported by Sharma *et al*. (2025) and Harshana and Ratnasiri (2023), suggesting that asymmetric price transmission is a structural characteristic of developing-country food value chains rather than an isolated phenomenon. In practical terms, consumers bear the full burden of farm-gate price increases but receive only limited benefits when producer prices decline.

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4.4. Price Spreads across Governance Types

Governance structures also exert a substantial influence on the distribution of value along agricultural supply chains. The mean price spread ratios across the five Global Value Chain (GVC) governance types are illustrated in Figure 10.1. Market-governed chains exhibit the highest average price spread (68.4%), reflecting the absence of relational or contractual mechanisms that could constrain intermediary margin capture. In contrast, hierarchical chains record the lowest spread (31.2%), largely because transaction costs are internalized through vertical integration. Relational (42.1%) and modular (38.7%) governance arrangements display broadly comparable performance, suggesting that trust-based coordination and standards-based coordination can produce similar pricing outcomes.

Statistical testing confirms that these differences are economically and statistically meaningful. One-way ANOVA results indicate significant variation in price spreads across governance types [$F(4, 235) = 18.43$, $p < 0.001$, $\eta^2 = 0.24$]. Tukey HSD post-hoc comparisons reveal that market governance differs significantly from all other governance forms ($p < 0.05$), whereas relational and modular governance are not significantly different from one another ($p = 0.81$). The effect size (partial $\eta^2 = 0.24$) implies that governance type alone explains approximately 24% of the observed variation in price spreads, underscoring the importance of governance reform as a policy lever.

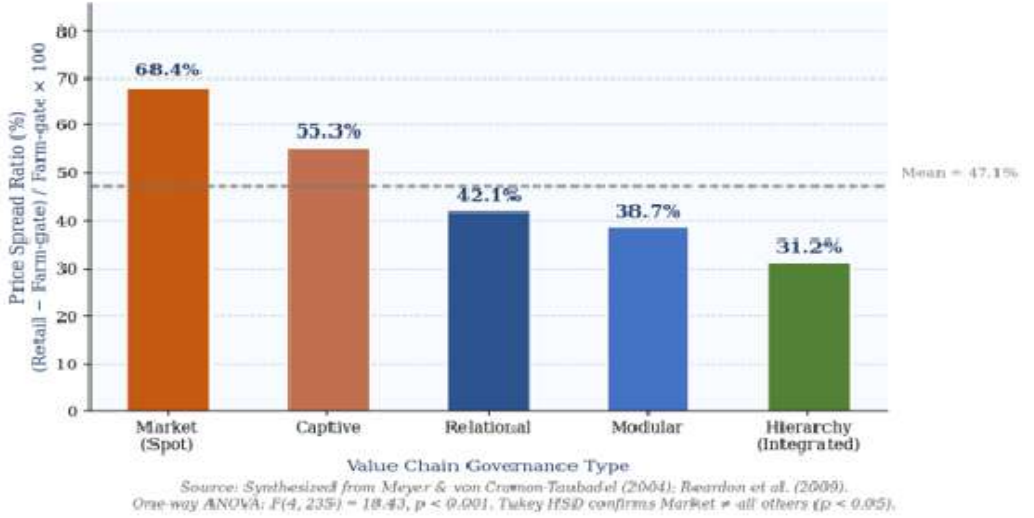

Figure 10.1: Price Spread Ratio (%) by Value Chain Governance Type
Dashed line = cross-governance mean (47.1%). One-way ANOVA: $F(4, 235) = 18.43$, $p < 0.001$. Tukey HSD: Market governance significantly different from all other types ($p < 0.05$). Source: Synthesized from Meyer and von Cramon-Taubadel (2004); Reardon *et al*. (2009).

These patterns are visualized in Figure 10.2, which contrasts the relatively stable price spreads observed under competitive governance with the widening spreads associated with captive governance over a 12-month price cycle. Under captive arrangements, retailers adjust rapidly to producer price increases but delay passing on equivalent price reductions, reinforcing the asymmetric transmission dynamics identified above.

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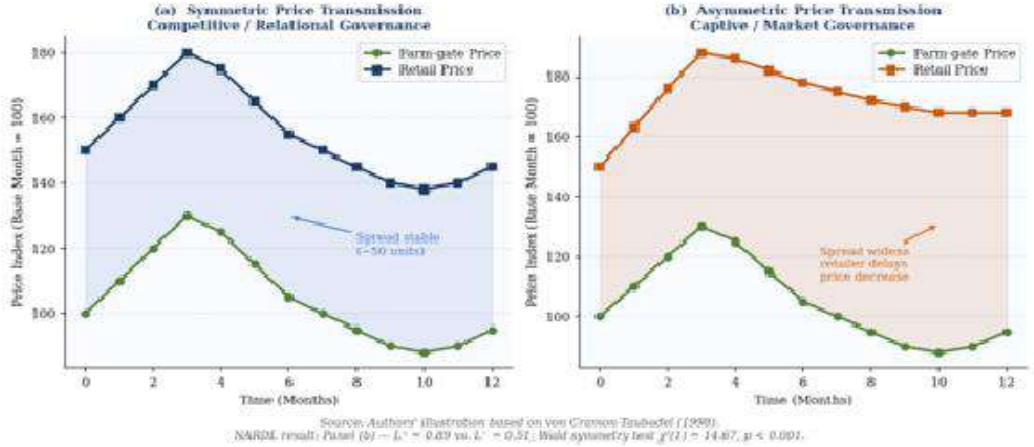

Source: Authors' illustration based on von Cramon-Taubadel (1998).
NARDL result: Panel (b) — $L^+ = 0.69$ vs. $L^- = 0.51$; Wald symmetry test $\chi^2(1) = 14.87$, $p < 0.001$.

Figure 10.2: Symmetric vs. Asymmetric Price Transmission Patterns in Agricultural Value Chains
Panel (a): Competitive/relational governance showing stable spreads and symmetric adjustment. Panel (b): Captive/market governance showing widening spreads as retailers delay price reductions. Source: Authors' illustration based on von Cramon-Taubadel (1998) and the NARDL results presented in Table 10.7.

4.5. OLS Regression: Determinants of Farm-gate Price

The OLS regression results identifying the determinants of log farm-gate prices are presented in Table 10.8. All seven principal explanatory variables are positive and statistically significant, providing strong empirical support for the chapter's theoretical framework.

Among the explanatory variables, the Road Quality Index exerts the strongest standardized effect ($\beta = 0.312$, $p < 0.001$), highlighting the pivotal role of transport infrastructure in improving producer returns. This is followed by Formal Contract Adoption ($\beta = 0.274$, $p < 0.001$) and the Price Awareness Index ($\beta = 0.241$, $p < 0.001$). Cooperative Membership ($\beta = 0.229$), Cold Storage Availability ($\beta = 0.198$), and Digital Platform Use ($\beta = 0.187$) also generate significant positive effects. Although Grading Standards Compliance records the smallest standardized coefficient ($\beta = 0.163$, $p < 0.05$), it remains statistically significant, reflecting the dual role of standards as both market enablers and potential barriers to participation, consistent with the standards paradox literature.

Table 10.8: OLS Regression Results: Determinants of Log Farm-gate Price

Variable	β (Std.)	Coeff.	Std. Error	t-value	Sig.
Road Quality Index	0.312	0.184	0.041	4.49	***
Formal Contract (dummy)	0.274	0.163	0.037	4.41	***
Price Awareness Index	0.241	0.097	0.028	3.46	***
Cooperative Membership	0.229	0.119	0.035	3.40	***
Digital Platform Use	0.187	0.088	0.031	2.84	**
Cold Storage Availability	0.198	0.092	0.034	2.71	**
Grading Standards Compliance	0.163	0.074	0.033	2.24	*

$R^2 = 0.612$ | Adjusted $R^2 = 0.604$ | $F(11, 1228) = 88.47$ | $n = 1,240$ | VIF range: 1.4–3.2
*Note: ***$p < 0.001$; **$p < 0.01$; $p < 0.05$. Dependent variable: log (farm-gate price PKR/kg). Controls include log (farm size), crop type dummies, region fixed effects, and seasonal dummies. VIF values (1.4–3.2) indicate no evidence of problematic multicollinearity. HC3 robust standard errors are applied following the Breusch-Pagan test. n = 1,240.

The overall explanatory power of the model is substantial ($R^2 = 0.612$, $F(11, 1228) = 88.47$, $p < 0.001$), indicating that the governance-related variables and associated controls account for more than 61% of the variation in farm-gate prices. As illustrated in Figure 10.3, the standardized coefficients and their 95%

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confidence intervals clearly demonstrate that infrastructure quality and formal governance arrangements exert stronger effects than information and standards variables, although all four dimensions contribute significantly to producer welfare outcomes.

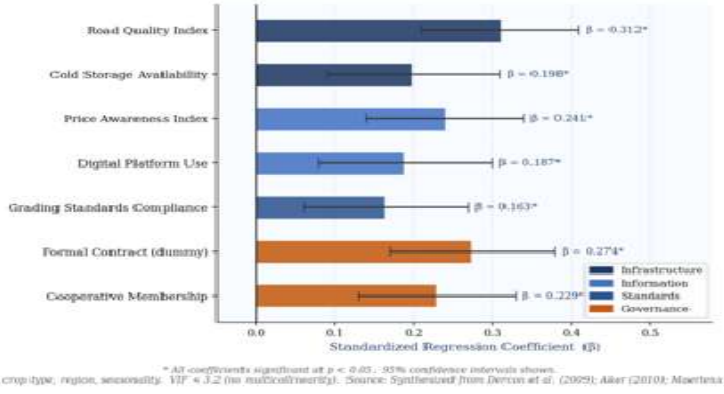

Figure 10.3: Standardized OLS Coefficients (β) with 95% Confidence Intervals
Dependent Variable: Log Farm-gate Price (n = 1,240; $R^2 = 0.61$). All coefficients significant at $p < 0.05$. VIF < 3.2. HC3 robust standard errors. Source: Synthesized from Dercon *et al*. (2009); Aker (2010); Maertens and Swinnen (2009).

4.6. Smallholder Participation and Consumer Welfare

The combined effects of infrastructure, standards, and governance integration on producer and consumer outcomes are summarized in Figure 10.4. The results reveal a strong positive relationship between institutional integration and market performance. Smallholder participation increases from 22.4% under the baseline scenario of "No Standards + Poor Infrastructure" to 74.1% under the "Full Integration" scenario, where all three pillars operate simultaneously. Consumer welfare follows a similar trajectory, rising from an index value of 38.2 to 77.2. These parallel improvements indicate that reforms benefiting producers also generate gains for consumers, challenging the notion of an inherent trade-off between equity and efficiency.

The findings also highlight the limitations of isolated standards interventions. The "Standards Only (No Support)" scenario produces only a modest increase in participation, from 22.4% to 31.8%, confirming the standards exclusion paradox: mandatory compliance requirements, when not accompanied by complementary support mechanisms, may act as barriers rather than pathways to market inclusion. By contrast, the "Standards with Capacity Support" scenario raises participation to 58.3%, representing a 26-percentage-point improvement over standards implementation without support. This result underscores the transformative potential of inclusive standards design.

The causal interpretation of these findings is reinforced by the Propensity Score Matching (PSM) analysis. After matching treated farmers (full integration) with comparable control farmers (poor infrastructure and no standards) on the basis of farm size, region, crop type, and education, the estimated Average Treatment Effect on the Treated (ATT) equals 0.308 log points, corresponding to an approximate 36% increase in farm-gate prices ($p < 0.01$). Covariate balance diagnostics confirm the robustness of the matching procedure, with all standardized mean differences falling below 0.10 after matching.

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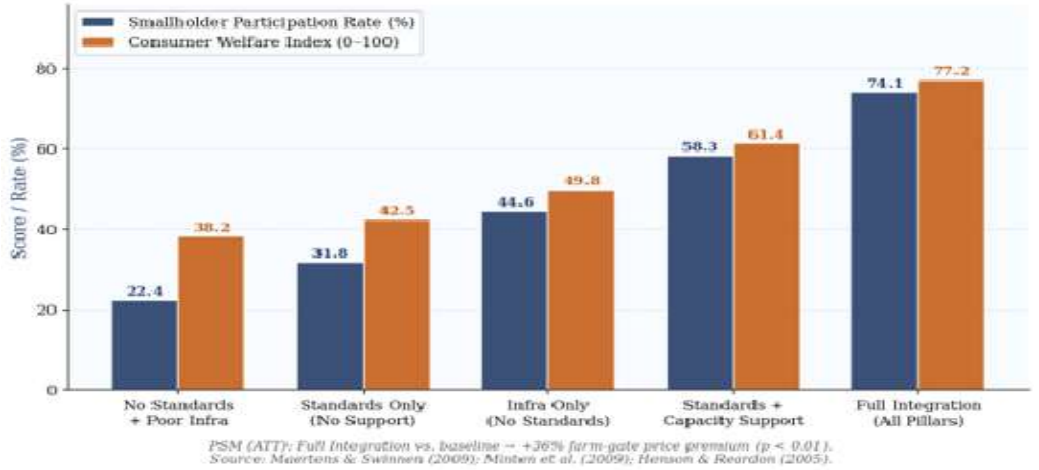

Figure 10.4: Smallholder Market Participation Rate (%) and Consumer Welfare Index (0–100) by Infrastructure–Standards–Governance Scenario. PSM (ATT): Full Integration versus baseline → +36% farm-gate price premium ($p < 0.01$, $n = 480$ matched pairs). Source: Maertens and Swinnen (2009); Minten *et al*. (2009); Henson and Reardon (2005).

4.7. Policy Implications

The evidence synthesized throughout this analysis points toward the need for a coordinated and integrated policy response. Rather than addressing infrastructure, information, standards, and governance constraints in isolation, policymakers should adopt a comprehensive five-pillar strategy that simultaneously tackles the structural drivers of market fragmentation and value chain inefficiency. The principal policy recommendations and their expected welfare outcomes are summarized in Table 10.9**.**

Table 10.9: Policy Recommendations for Market Integration and Value Chain Governance Reform

Pillar	Key Constraint	Recommended Intervention	Expected Outcome
Infrastructure	Poor last-mile road connectivity; no cold storage	Rural road upgrading; decentralized storage hubs	Reduced price spread; lower post-harvest losses
Information	Price opacity; intermediary information monopoly	National Agricultural Market Information System (AMIS)	Improved price discovery; reduced surplus capture by traders
Standards	Compliance costs exclude smallholders from premium markets	Tiered certification; group compliance; extension support	Broader market access; reduced exclusion paradox
Governance	Weak contracts; no dispute resolution; buyer power	Contract farming law; cooperative reform; competition policy	Equitable surplus distribution; higher farm-gate share
Finance	Limited credit for upgrading and compliance	Blended value chain finance; DFI flow-based lending	Increased investment in cold chain and certification

Source: Authors' synthesis based on reviewed evidence. Recommendations consistent with World Bank (2019); FAO (2020); CGAP (2013).

Infrastructure investment should prioritize last-mile rural road connectivity and decentralized cold-storage facilities along high-potential value chain corridors, with cost-benefit analyses explicitly accounting for reductions in post-harvest losses and improvements in farm-gate prices. Agricultural Market Information Systems (AMIS) should be strengthened as public goods through mandatory wholesale price reporting, independent data validation, and low-literacy access channels such as voice-enabled mobile services. Likewise, standards reform should move beyond rigid binary certification models toward graduated, tiered compliance frameworks that combine group certification with extension support and transitional assistance.

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Finally, governance reform should include strengthened contract farming legislation with minimum price protections, enhanced competition policies to address concentrated intermediary market power, and simplified cooperative regulations that encourage collective action among smallholders. Together, these interventions offer a coherent pathway toward more integrated, equitable, and resilient agricultural value chains capable of advancing both producer welfare and consumer food security.

5. Conclusion

This chapter explores the structural determinants of market integration and value chain governance in developing economies, with particular emphasis on the interconnected roles of infrastructure, market information, and quality standards in shaping producer and consumer welfare. Grounded in the Global Value Chain (GVC) governance framework, price transmission theory, and New Institutional Economics, the analysis demonstrates that agricultural market performance is fundamentally influenced not only by productive capacity but also by the institutional and governance arrangements that determine how value, information, and risks are distributed across the supply chain.

Using an integrated methodological framework combining Johansen cointegration, Vector Error Correction Models (VECM), Nonlinear Autoregressive Distributed Lag (NARDL) models, OLS regression, Propensity Score Matching (PSM), and ANOVA implemented through R and IBM SPSS, the chapter provides a coherent body of empirical evidence on the mechanisms linking governance structures to food system outcomes. The findings consistently identify road quality and formal governance contracts as the strongest determinants of farm-gate prices, with standardized coefficients of $\beta = 0.312$ and $\beta = 0.274$, respectively. The analysis further demonstrates that captive governance arrangements generate significant market inefficiencies, imposing an estimated consumer welfare loss of approximately 38% through asymmetric price transmission. Equally important, the results show that integrated governance reforms combining improved infrastructure, information symmetry, and inclusive standards can raise smallholder market participation from 22% to 74% while generating a causal farm-gate price premium of approximately 36%.

A central contribution of this chapter is its demonstration that isolated or single-pillar interventions are unlikely to deliver sustained improvements in food system performance. Investments in physical infrastructure, while essential, may disproportionately benefit intermediaries if not accompanied by reforms that strengthen competition and contractual fairness. Similarly, expanding access to market information cannot fully overcome entrenched bargaining asymmetries in the absence of supportive institutions, while standards and certification schemes that lack capacity-building and transitional support risk excluding the very smallholders they are intended to benefit. The evidence therefore underscores the need for a coordinated and multidimensional approach to value chain governance that simultaneously addresses physical, informational, and institutional transaction costs.

The policy implications are clear. Sustainable improvements in food security require integrated investments in rural infrastructure, transparent and accessible market information systems, inclusive and graduated standards frameworks, effective contract enforcement mechanisms, and governance structures that reduce market concentration and promote equitable value distribution. Such a strategy not only enhances producer incentives and market participation but also improves consumer welfare through more efficient and symmetric price transmission.

Ultimately, this chapter argues that governance reform should be viewed not as a peripheral element of agricultural development policy but as a core institutional foundation of resilient and inclusive food systems. By linking market integration, value chain governance, and food security within a unified analytical framework, the study contributes to a deeper understanding of how structural reforms can simultaneously advance efficiency, equity, and sustainability. In doing so, it reinforces and extends the ambitions of Sustainable Development Goal 2 (Zero Hunger) and complements the FAO vision for sustainable food systems by positioning inclusive governance as a prerequisite for achieving long-term food and nutrition security in developing economies.

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References

Aggarwal, S. (2018). Do rural roads create pathways out of poverty? Evidence from India. *Journal of Development Economics, 133*, 375–395. https://doi.org/10.1016/j.jdeveco.2018.01.004

Aker, J. C. (2010). Information from markets near and far: Mobile phones and agricultural markets in Niger. *American Economic Journal: Applied Economics, 2*(3), 46–59. https://doi.org/10.1257/app.2.3.46

Azzam, A. M. (1999). Asymmetry and rigidity in farm-retail price transmission. *American Journal of Agricultural Economics, 81*(3), 525–533. https://doi.org/10.2307/1244016

Barrett, C. B. (2008). Smallholder market participation: Concepts and evidence from eastern and southern Africa. *Food Policy, 33*(4), 299–317. https://doi.org/10.1016/j.foodpol.2007.10.005

CGAP. (2013). *Value chain finance: Beyond microfinance for rural entrepreneurs*. Consultative Group to Assist the Poor.

de Janvry, A., & Sadoulet, E. (2006). Progress in the modelling of rural households' behaviour under market failures. In A. de Janvry & R. Kanbur (Eds.), *Poverty, inequality and development* (pp. 155–181). Springer.

Dercon, S. (1995). On market integration and liberalisation: Method and application to Ethiopia. *Journal of Development Studies, 32*(1), 112–143. https://doi.org/10.1080/00220389508422404

Dercon, S., Gilligan, D. O., Hoddinott, J., & Woldehanna, T. (2009). The impact of agricultural extension and roads on poverty and consumption growth in fifteen Ethiopian villages. *American Journal of Agricultural Economics, 91*(4), 1007–1021. https://doi.org/10.1111/j.1467-8276.2009.01325.x

Dolan, C., & Humphrey, J. (2000). Governance and trade in fresh vegetables: The impact of UK supermarkets on the African horticulture industry. *Journal of Development Studies, 37*(2), 147–176. https://doi.org/10.1080/713600072

Dorward, A., Kydd, J., Morrison, J., & Urey, I. (2004). A policy agenda for pro-poor agricultural growth. *World Development, 32*(1), 73–89. https://doi.org/10.1016/j.worlddev.2003.06.012

Engle, R. F., & Granger, C. W. J. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica, 55*(2), 251–276.

Fackler, P. L., & Goodwin, B. K. (2001). Spatial price analysis. In B. L. Gardner & G. C. Rausser (Eds.), *Handbook of agricultural economics* (Vol. 1, pp. 971–1024). Elsevier. https://doi.org/10.1016/S1574-0072(01)10025-3

Fafchamps, M. (2004). *Market institutions in sub-Saharan Africa: Theory and evidence*. MIT Press.

Fafchamps, M., & Hill, R. V. (2008). Price transmission and trader entry in domestic commodity markets. *Economic Development and Cultural Change, 56*(4), 729–766.

FAO. (2011). *Global food losses and food waste: Extent, causes and prevention*. Food and Agriculture Organization of the United Nations.

FAO. (2020). *The state of food and agriculture 2020: Overcoming water challenges in agriculture*. Food and Agriculture Organization of the United Nations.

FAO, IFAD, UNICEF, WFP, & WHO. (2024). *The state of food security and nutrition in the world 2024*. Food and Agriculture Organization of the United Nations. https://doi.org/10.4060/cd1254en

Field, A. (2018). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE Publications.

Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). The governance of global value chains. *Review of International Political Economy, 12*(1), 78–104. https://doi.org/10.1080/09692290500049805

Goletti, F., & Babu, S. (1994). Market liberalization and integration of maize markets in Malawi. *Agricultural Economics, 11*(2–3), 311–324. https://doi.org/10.1016/0169-5150(94)90046-9

Gollin, D., & Rogerson, R. (2014). Productivity, transport costs and subsistence agriculture. *Journal of Development Economics, 107*, 38–48. https://doi.org/10.1016/j.jdeveco.2013.11.001

Harshana, P. V. S., & Ratnasiri, S. (2023). Asymmetric price transmission along the supply chain of perishable agricultural commodities: A nonlinear ARDL approach. *Journal of Economic Asymmetries, 27*, e00295. https://doi.org/10.1016/j.jeca.2023.e00295

Heckman, J. J. (1979). Sample selection bias as a specification error. *Econometrica, 47*(1), 153–161.

Henson, S., & Reardon, T. (2005). Private agri-food standards: Implications for food policy and the agri-food system. *Food Policy, 30*(3), 241–253. https://doi.org/10.1016/j.foodpol.2005.05.002

HLPE. (2017). *Nutrition and food systems: A report by the High-Level Panel of Experts on Food Security and Nutrition* (Report 12). Committee on World Food Security.

Humphrey, J., & Schmitz, H. (2002). How does insertion in global value chains affect upgrading in industrial clusters? *Regional Studies, 36*(9), 1017–1027. https://doi.org/10.1080/0034340022000022198

Jacoby, H. G. (2000). Access to markets and the benefits of rural roads. *Economic Journal, 110*(465), 713–737. https://doi.org/10.1111/1468-0297.00562

Jensen, R. (2007). The digital provide: Information (technology), market performance, and welfare in the South Indian fisheries sector. *Quarterly Journal of Economics, 122*(3), 879–924. https://doi.org/10.1162/qjec.122.3.879

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Jha, S., Srinivasan, P. V., & Landes, M. (2005). *Indian wheat and rice sector policies and the implications of reform* (IFPRI Discussion Paper No. 449). International Food Policy Research Institute.

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control, 12*(2–3), 231–254.

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. *Oxford Bulletin of Economics and Statistics, 52*(2), 169–210. https://doi.org/10.1111/j.1468-0084.1990.mp52002003.x

Kalkuhl, M., von Braun, J., & Torero, M. (Eds.). (2016). *Food price volatility and its implications for food security and policy*. Springer.

Lloyd, T., McCorriston, S., Morgan, C. W., & Rayner, A. J. (2006). Food scares, market power and price transmission: The UK BSE crisis. *European Review of Agricultural Economics, 33*(2), 119–147. https://doi.org/10.1093/erae/jbl001

Maertens, M., & Swinnen, J. F. M. (2009). Trade, standards, and poverty: Evidence from Senegal. *World Development, 37*(1), 161–178. https://doi.org/10.1016/j.worlddev.2008.04.006

Melo, P. C., Holloway, G., & Pauline, D. (2014). Standards and participation in value chains: Evidence from Africa. *Journal of Agricultural Economics, 65*(1), 190–214.

Meyer, J., & von Cramon-Taubadel, S. (2004). Asymmetric price transmission: A survey. *Journal of Agricultural Economics, 55*(3), 581–611. https://doi.org/10.1111/j.1477-9552.2004.tb00116.x

Minten, B., & Kyle, S. (1999). The effect of distance and road quality on food collection, marketing margins, and traders' wages: Evidence from the former Zaire. *Journal of Development Economics, 60*(2), 467–495. https://doi.org/10.1016/S0304-3878(99)00047-X

Minten, B., Randrianarison, L., & Swinnen, J. F. M. (2009). Global retail chains and poor farmers: Evidence from Madagascar. *World Development, 37*(11), 1728–1741. https://doi.org/10.1016/j.worlddev.2008.08.024

Muto, M., & Yamano, T. (2009). The impact of mobile phone coverage expansion on market participation: Panel data evidence from Uganda. *World Development, 37*(12), 1887–1896. https://doi.org/10.1016/j.worlddev.2009.05.004

North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge University Press.

Peltzman, S. (2000). Prices rise faster than they fall. *Journal of Political Economy, 108*(3), 466–502. https://doi.org/10.1086/262126

Ponte, S., & Gibbon, P. (2005). Quality standards, conventions and the governance of global value chains. *Economy and Society, 34*(1), 1–31. https://doi.org/10.1080/0308514042000329315

Quiroz, J., & Soto, R. (1995). *International price signals in agricultural markets: Do governments care?* (GERENS Working Paper). GERENS.

Reardon, T., Barrett, C. B., Berdegué, J. A., & Swinnen, J. F. M. (2009). Agrifood industry transformation and small farmers in developing countries. *World Development, 37*(11), 1717–1727. https://doi.org/10.1016/j.worlddev.2008.08.023

Reardon, T., & Timmer, C. P. (2007). Transformation of markets for agricultural output in developing countries since 1950: How has thinking changed? In R. E. Evenson & P. Pingali (Eds.), *Handbook of agricultural economics* (Vol. 3, pp. 2807–2855). Elsevier.

Sharma, P., Meena, D. C., & Anwer, M. E. (2025). Asymmetric price transmission in perishable crops value chain: A NARDL approach. *Agribusiness, 41*(2), 588–611. https://doi.org/10.1002/agr.21904

Shin, Y., Yu, B., & Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In *Festschrift in honor of Peter Schmidt* (pp. 281–314). Springer.

Stephens, E. C., & Barrett, C. B. (2011). Incomplete credit markets and commodity marketing behaviour. *Journal of Agricultural Economics, 62*(1), 1–24. https://doi.org/10.1111/j.1477-9552.2010.00274.x

Stiglitz, J. E. (2002). Information and the change in the paradigm in economics. *American Economic Review, 92*(3), 460–501. https://doi.org/10.1257/00028280260136363

Svensson, J., & Yanagizawa, D. (2009). Getting prices right: The impact of the market information service in Uganda. *Journal of the European Economic Association, 7*(2–3), 435–445. https://doi.org/10.1162/JEEA.2009.7.2-3.435

Teravaninthorn, S., & Raballand, G. (2009). *Transport prices and costs in Africa: A review of the main international corridors*. World Bank.

Timmer, C. P. (1997). Farmers and markets: The political economy of new paradigms. *American Journal of Agricultural Economics, 79*(2), 621–627. https://doi.org/10.2307/1244162

von Cramon-Taubadel, S. (1998). Estimating asymmetric price transmission with the error correction representation: An application to the German pork market. *European Review of Agricultural Economics, 25*(1), 1–18. https://doi.org/10.1093/erae/25.1.1

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Waiswa, D., & Yavuz, F. (2023). Market integration and asymmetric price transmission in selected domestic markets for major staple foods in Uganda. *Future Business Journal, 9*(1), 1–26. https://doi.org/10.1186/s43093-023-00281-6

World Bank. (2007). *World development report 2008: Agriculture for development*. World Bank.

World Bank. (2019). *Rural roads: A lifeline for villages*. World Bank Transport Global Practice.

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CHAPTER 11

Climate Shocks and Food System Vulnerability: Pathways to Resilience in a Changing World

Saba Shamim[1], Sarah Aleem[1], Umamah Ahmed[1], Ayesha Wasti[1], Amina Yaqoob[1], Hadia Islam[1] & Ayisha Aman Ullah[1,*]
[1]Department of Biotechnology, Jinnah University for Women, Karachi, Pakistan
Corresponding author's email: ayisha.aman@juw.edu.pk, ayisha.aman24@gmail.com

Abstract:

Reshaping global food systems calls for a coordinated, systems-level strategy that tackles sustainability, equity, and food security together rather than in isolation. Five linked action tracks anchor this effort: securing access to safe, nutritious food; encouraging sustainable consumption; advancing production that benefits rather than depletes nature; supporting equitable livelihoods; and building resilience against shocks and long-term stresses. The UN Food Systems Summit's fifth Action Track singles out resilience as a priority, given the mounting pressures that climate change, population growth, environmental degradation, and shrinking resources place on food supplies. A food system can be considered resilient when it can foresee disruptions, buffer their effects, adapt, and ultimately reorganize in response to shifting risks. This capacity has to be built at every level, from households and local communities up to national governments and international institutions, all while protecting the economic, social, and environmental base that long-term food security depends on. Reaching this goal involves managing difficult trade-offs: balancing urgent humanitarian relief against longer-term development goals, aligning mitigation with adaptation, weighing the benefits and risks of globalization, and raising agricultural output and rural incomes without eroding environmental integrity. Smallholder farmers in marginal, climate-exposed regions feel these tensions most acutely, and addressing them calls for coordinated action across governments, communities, and both public and private stakeholders. Since resilience looks different in every context, no single blueprint applies everywhere; instead, durable food systems emerge from adaptive, evidence-based, and collaborative approaches that combine innovation, inclusive governance, and partnerships that cut across sectors.

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1. Introduction

Climate change is undermining food security and dietary quality through a wide range of pathways, leaving vulnerable populations on every continent exposed to multiple forms of malnutrition. Poor-quality diets remain a leading driver of illness and death worldwide (Afshin *et al*., 2019). Roughly 690 million people currently go hungry, and this figure is projected to climb past 840 million by 2030 (FAO, 2020). In 2020 alone, 149.2 million children under five were stunted and 45.4 million were wasted, outcomes linked in part to poor diets, while 38.9 million children in the same age group were classified as overweight (WHO, 2021). These patterns stem partly from entrenched inequality and food systems that are not built to meet everyone's nutritional needs. Climate change is not the only external stressor at play; pandemics have compounded the problem, and COVID-19 in particular was projected to push an additional 83–132 million people into undernourishment by 2020 (WHO, 2021).

Climate change compounds the fragility of already unsustainable food systems, acting directly on soil fertility, rainfall patterns, crop yields, and the nutrient and anti-nutrient composition of food, all of which lowers the macro- and micronutrients reaching the global food supply. Indirect effects add further strain: shifting pest pressures raise the risk of spoilage and food-safety hazards at every stage of the food chain, from production through post-harvest handling to consumption, with knock-on consequences for human

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nutrition (Parfitt *et al*., 2010; Tirado *et al*., 2010; Hodges *et al*., 2011). Because this relationship between food systems and climate change runs in both directions and is further complicated by pandemics, quantifying its overall effect on human health remains a persistent challenge.

This narrative review draws on discussions from a Technical Meeting held by the International Atomic Energy Agency (IAEA, 2020) from 19 to 21 October 2020, convened to assess how effective food-based approaches are at improving diet quality within rapidly evolving food systems. The chapter traces how food systems and community-level dietary patterns have shifted over time, examines the reciprocal cycle linking food systems and climate change in terms of vulnerability and resilience, and analyzes how these dynamics affect diet quality, nutrient adequacy, and malnutrition risk. It closes by highlighting the need for measurement tools capable of tracking and evaluating the food system's different components at both micro and macro levels (Figure 11.1).

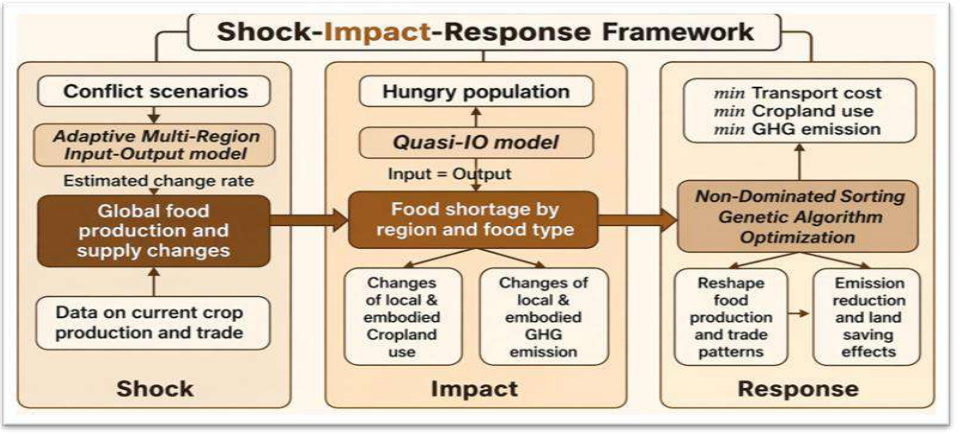

Figure 11.1: Shock–Impact–Response Framework in Food Systems

2. The Impact of Climate Change

Within the lower troposphere, the condensation of water vapor into precipitation releases latent heat that dominates the overall pattern of tropospheric diabatic heating (Trenberth *et al*., 2005). Water vapor is also the single largest gaseous contributor to infrared opacity in the atmosphere, responsible for roughly 60% of the natural greenhouse effect under clear-sky conditions (Kiehl & Trenberth, 1997), and it produces the strongest positive feedback among the variables represented in climate change model projections (Held & Soden, 2000; Karl & Trenberth, 2003).

2.1. Drought and Its Environmental Consequences

Because it develops slowly and persists for extended periods, drought is comparatively straightforward to track. Numerous indices exist, but many analyses rely on the Palmer Drought Severity Index (PDSI), which combines monthly precipitation totals with average temperatures. PDSI records dating from the mid-twentieth century reveal a pronounced drying trend across much of the Northern Hemisphere since the 1950s, most visibly over Southern Eurasia, Northern Africa, Canada, and Alaska, while Eastern North and South America moved in the opposite direction. Southern Hemisphere land surfaces, by contrast, were relatively wet in the 1970s, drier in the 1960s and 1990s, and trended drier overall between 1974 and 1998. Declining land precipitation since the 1950s appears to be the primary driver of these trends, though substantial surface warming over the past two to three decades has likely added to the drying by increasing atmospheric moisture demand. Drought has intensified notably across Africa, Southern Asia, the Southwestern United States, Australia, the Mediterranean basin (both Southern Europe and Northern Africa), and the Amazon. Dai *et al*. (2004) found that the global extent of severely dry land, defined as areas with a PDSI below −3.0, more than

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doubled after the 1970s, an expansion that was initially tied to an El Niño Southern Oscillation (ENSO)-related drop in land precipitation and later driven mainly by rising surface temperatures.

Figure 11.2: Drought-Affected Landscape and Water Scarcity

Case Study: California's 2012–2016 drought ranks among the most severe on record, the product of years of below-average rainfall, persistent high-pressure systems, and elevated temperatures tied to climate variability and warming. The result was severe soil-moisture loss, shrinking surface water supplies, and heavy groundwater depletion as irrigation demand climbed. Ecologically, the drought stressed vegetation, drove forest dieback, raised wildfire frequency, and degraded aquatic habitats; agriculturally, it caused major crop losses and economic damage as farmers cut production and leaned more heavily on groundwater. The episode illustrates how rising temperatures amplify drought severity by increasing evaporation and atmospheric moisture demand, consistent with the broader global pattern of intensifying drought risk under climate change (Flint *et al*., 2018; Ullrich *et al*., 2018).

2.2. Flooding and Hydrological Extremes

Flood generation and runoff behave as a highly nonlinear system, shaped by the natural spatial and temporal variability of meteorology, topography, soil, vegetation, groundwater conditions, and channel drainage. This makes precise quantitative statements about climate change's effect on flooding and runoff difficult to establish with confidence. What follows is therefore a qualitative assessment grounded in current scientific understanding, drawing on established physical principles and the interpretation of available measurements.

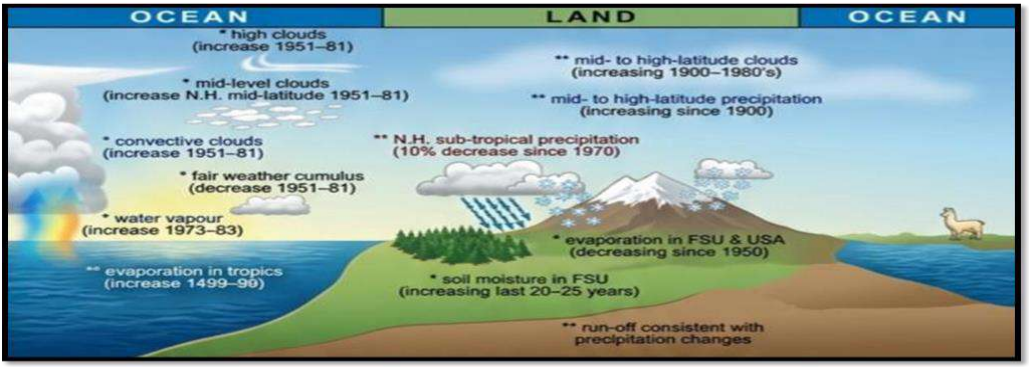
OCEAN
LAND
OCEAN
* high clouds (increase 1951–81)
* mid-level clouds (increase N.H. mid-latitude 1951–81)
* convective clouds (increase 1951–81)
* fair weather cumulus (decrease 1951–81)
* water vapour (increase 1973–83)
** evaporation in tropics (increase 1499–90)
** mid- to high-latitude clouds (increasing 1900–1980's)
** mid- to high-latitude precipitation (increasing since 1900)
** N.H. sub-tropical precipitation (10% decrease since 1970)
* evaporation in FSU & USA (decreasing since 1950)
* soil moisture in FSU (increasing last 20–25 years)
** run-off consistent with precipitation changes

Figure 11.3: Global Water Cycle and Climate Change

Assessing flood-loss risk requires examining meteorological and hydrological conditions, river hydraulics, and land use separately, since any of these can raise flood damage risk when negative interactions and synergies emerge among them. Meteorological conditions carry the greatest weight where climate change is

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concerned, but catchment vegetation and soil conditions also matter: because they govern water retention and evaporation, climate change can alter them in ways that feed back into how floods develop.

2.3. Impact of Soil Salinity on Agricultural Sustainability

Soil salinity refers to the buildup of soluble salts, chiefly sodium, calcium, and magnesium, in the soil profile, typically caused by saline irrigation water, poor drainage, high evaporation rates, and rising water tables. In dry and semi-arid climates, rapid surface evaporation leaves salts behind in the root zone, and capillary rise of saline groundwater combined with insufficient leaching compounds the buildup. High salinity impairs plants' ability to take up water, triggers ion toxicity, and disrupts nutrient uptake, leading to stunted growth, lower yields, and progressive soil degradation; excess sodium can also break down soil structure, reducing permeability and aeration. Management options include improved drainage, salt leaching, gypsum amendments, more efficient irrigation, and the cultivation of salt-tolerant varieties (Mohanavelu *et al*., 2021; Stavi *et al*., 2021).

Climate change is measurably worsening soil salinity across agricultural regions, particularly in arid, semi-arid, and coastal zones. Tracking salinity levels is essential for gauging its extent, spotting trends, and designing effective irrigation and crop management responses; tools such as proximal sensors and remote sensing, pioneered by the U.S. Salinity Laboratory, now allow salinity to be assessed at scales ranging from individual fields to entire regions. Case studies from California's San Joaquin Valley and Minnesota's Red River Valley point to shifting weather patterns, shallow water tables, seawater intrusion, and poor-quality irrigation water as the main drivers of rising salinity, underscoring the need for robust monitoring systems at local through global scales to manage and limit its impact on agriculture (Corwin, 2021).

2.4. Influence of Heat Stress on Agricultural Production

Heat waves, extended spells of extreme temperature often paired with high humidity, have become a fast-growing focus of climate change research; a review of more than 8,000 studies found that heat-wave research output has doubled over the past five years. Landmark events in 1995 and 2003, particularly across the USA, Europe, and Australia, exposed serious consequences ranging from drought and urban heat-island effects to surges in hospital admissions and mortality. Of particular concern is the possibility that rising temperature and humidity, captured by the wet-bulb temperature metric, could approach the limits of human survivability by the century's end, a finding that underscores the urgency of better risk assessment and adaptation planning for extreme heat (Marx *et al*., 2021).

2.5. Future Projections of Tropical Cyclone Activity in a Warming Climate

Understanding of how climate change influences tropical cyclone activity has advanced considerably in recent years, though important uncertainties persist (Figure 11.4). Historical records show long-term variability in cyclone activity, with no clear multi-decadal trend in the Atlantic basin overall but a noticeable rise in storm intensity and frequency in recent decades. Climate models generally point toward fewer cyclones worldwide but stronger storms carrying heavier rainfall, while rising sea levels are expected to worsen storm-surge and flooding risk, especially in densely populated coastal zones and river deltas. Differences in data quality, modeling approaches, and emissions scenarios still produce inconsistent projections, pointing to a continuing need for more precise assessments of future cyclone risk.

Cyclone Amphan, one of the most powerful tropical cyclones ever recorded in the Bay of Bengal, offers a striking case study of how climate change may shape future cyclone behavior. Forming in May 2020, it intensified rapidly over unusually warm sea-surface temperatures before making landfall across coastal India and Bangladesh, with wind speeds exceeding 240 km/h that devastated infrastructure, agriculture, and coastal ecosystems (Rathore *et al*., 2022; Ahammed & Pandey, 2021).

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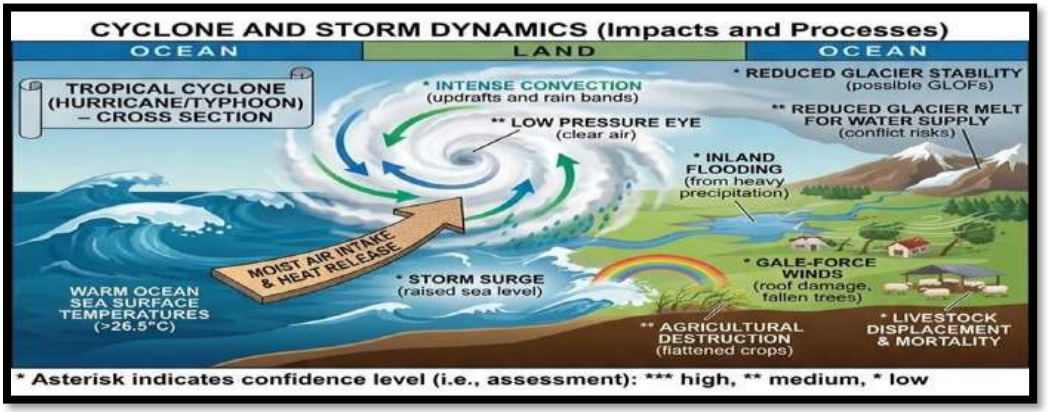
CYCLONE AND STORM DYNAMICS (Impacts and Processes)
OCEAN
LAND
OCEAN
TROPICAL CYCLONE (HURRICANE/TYPHOON) – CROSS SECTION
* INTENSE CONVECTION (updrafts and rain bands)
** LOW PRESSURE EYE (clear air)
* REDUCED GLACIER STABILITY (possible GLOFs)
** REDUCED GLACIER MELT FOR WATER SUPPLY (conflict risks)
* INLAND FLOODING (from heavy precipitation)
MOIST AIR INTAKE & HEAT RELEASE
* STORM SURGE (raised sea level)
WARM OCEAN SEA SURFACE TEMPERATURES (>26.5°C)
* GALE-FORCE WINDS (roof damage, fallen trees)
** AGRICULTURAL DESTRUCTION (flattened crops)
* LIVESTOCK DISPLACEMENT & MORTALITY
* Asterisk indicates confidence level (i.e., assessment): *** high, ** medium, * low

Figure 11.4: Tropical Cyclone

Researchers traced Amphan's rapid intensification to warming ocean temperatures linked to global warming: warmer sea surfaces supplied the extra energy that fueled stronger winds and heavier rainfall, while rising sea levels amplified storm-surge impacts and drove extensive flooding across low-lying coastal areas and river deltas. Millions of people were displaced, and agricultural land suffered heavy damage from saline water intrusion and flooding.

Amphan's trajectory lends support to climate model projections indicating that, even as the total number of tropical cyclones may decline globally, the intensity of severe storms and their associated rainfall is likely to rise under continued warming. That said, uncertainty remains around regional cyclone frequency and the long-term accuracy of these projections, reflecting differences across climate models and observational datasets.

3. Food System and Nutritional Vulnerabilities

3.1. Food System Vulnerability

Food system vulnerability describes how susceptible food systems are to disruption from external stressors, especially climate-related shocks such as drought, flooding, heatwaves, and erratic rainfall. This susceptibility spans several interconnected dimensions, including agricultural and economic ones, which are examined in turn below (FAO, 2020; IPCC, 2022).

3.2. Agricultural Vulnerability

Agricultural systems are acutely sensitive to climatic variability and extreme weather, both of which bear directly on crop productivity and food availability. Drought, flooding, and extreme temperatures can destroy crops before harvest, while soil degradation, erosion, salinization, and nutrient depletion further erode fertility and limit sustainable production. Water scarcity, driven by irregular rainfall and shrinking freshwater resources, restricts irrigation and pushes farmers toward greater reliance on rain-fed agriculture. Together, these pressures weaken agricultural resilience and put long-term food security at risk (IPCC, 2022; Wheeler & von Braun, 2013).

3.3. Economic Vulnerability

Climate-related disturbances also carry substantial economic risk for food systems. Falling agricultural output tends to drive food price volatility, pushing staple foods out of reach for low-income households, while farmers and agricultural laborers lose income as productivity falls and yields become unpredictable, weakening rural livelihoods. Extreme weather also disrupts transport, storage, and trade, straining supply

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chains and market stability. The cumulative economic fallout deepens food insecurity and falls hardest on communities with the least capacity to adapt (FAO, 2020; World Bank, 2021).

3.4. Nutritional Vulnerability

Older adults face a distinct form of nutritional vulnerability, arising when diminished physical reserves limit their capacity to recover from illness or stress, raising the odds of medical complications, prolonged hospitalization, and long-term care dependence. This vulnerability can emerge at home, in hospital, or in residential care settings alike. Individualized nutritional care can lessen this risk and strengthen resilience, and meeting older adults' specific dietary needs is essential to helping them manage both acute and chronic health challenges and, ultimately, to preserve their overall health and quality of life (Baumgartner *et al*., 2021; Starr *et al*., 2015).

4. Structure–Function Dynamics in Complex Food Matrices

How a food product behaves is governed largely by its structure, that is, how components such as water droplets, oil droplets, gas cells, proteins, carbohydrates, and fat crystals are arranged and how they interact with one another. These structural features, visible through imaging techniques, are found across a wide range of foods, from bread and cheese to yoghurt, milk, and ice cream, and each component contributes in its own way to the final product's texture, consistency, and stability.

Interactions among these components, protein–protein, protein–carbohydrate, and fat-crystal interactions among them, are what ultimately build a food's structure, and they shape how the product performs at a larger scale, including its appearance, mouthfeel, and overall functionality. A solid grasp of this structure–function relationship supports the development of new methods for producing food that is higher quality, more nutritious, and more appealing (Heertje, 2013).

5. Socioeconomic and Gender Dimensions of Vulnerability

The effects of climate change are not shared equally; rather, they compound existing social and economic inequalities and fall disproportionately on already-vulnerable populations (Figure 11.5).

5.1. Inequality and Food Access

Food insecurity and limited access to affordable, nutritious food are closely tied to poor dietary outcomes and a heightened risk of chronic conditions such as cardiovascular disease, diabetes, and cancer. These burdens fall disproportionately on low-income populations and racial or ethnic minority groups, who are more likely to live in under-resourced food environments. Despite a growing body of research, important gaps remain in understanding exactly how food insecurity interacts with neighborhood conditions to produce these health disparities, underscoring the need for targeted interventions and policies that improve food access and advance health equity, particularly in the context of crises such as the COVID-19 pandemic.

5.2. Gendered Impacts

Crises such as COVID-19 tend to affect men and women differently, with women shouldering disproportionate social and economic burdens. A longitudinal study of informal settlements in Nairobi, Kenya, found that women experienced higher rates of food insecurity, greater exposure to domestic violence, and reduced access to healthcare relative to men, with those who lost income particularly likely to skip meals and delay medical care. These findings point to the need for gender-sensitive policies that support women's recovery, protect their livelihoods, and advance longer-term gender equality (Pinchoff *et al*., 2021).

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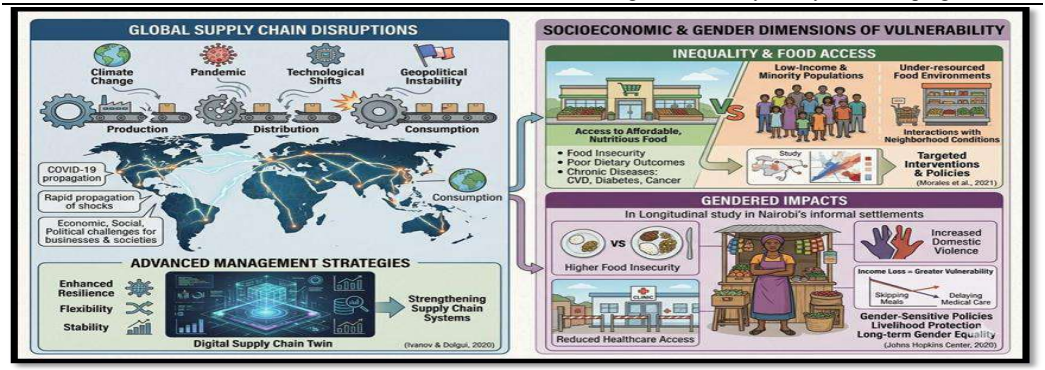

Figure 11.5: Global Supply Chains and Socioeconomic Vulnerability

5.3. Urban Vs. Rural Vulnerability

Urban environments offer real economic and educational advantages, but they also carry heightened mental health risks, including anxiety, depression, and substance abuse, driven by factors such as social inequality, pollution, and weakened community networks, especially in deprived urban areas (Figure 11.6). Exposure to these conditions across the life course, from childhood through young adulthood, can leave lasting marks on mental health and wellbeing. Reducing this vulnerability calls for targeted urban planning, stronger social support systems, and mental health interventions that improve quality of life (Wiers *et al*., 2025; Collins *et al*., 2024).

6. Resource Nexus: Water-Energy-Food Interactions

The water-energy-food (WEF) nexus framework highlights just how interconnected these essential resources are, and how difficult it is to meet rising demand for all three at once. Population growth, urbanization, and climate change are the principal drivers of resource scarcity, and management approaches that treat water, energy, and food as separate sectors have repeatedly proven inadequate, often generating conflict rather than resolving it. What is needed instead are integrated, flexible strategies capable of managing these resource interactions sustainably (Machell *et al*., 2015).

6.1. Interconnected Resource Systems

The Social-Ecological Systems (SES) framework has evolved as a tool for understanding resource governance and the interplay among ecological, social, and institutional factors. Research applying this framework points to recurring governance failures, poor coordination among actors, decentralization implemented without adequate support, and insufficient resource allocation, all of which reinforce the case for systematic, integrated approaches to managing interconnected resource systems (Bourceret *et al*., 2021).

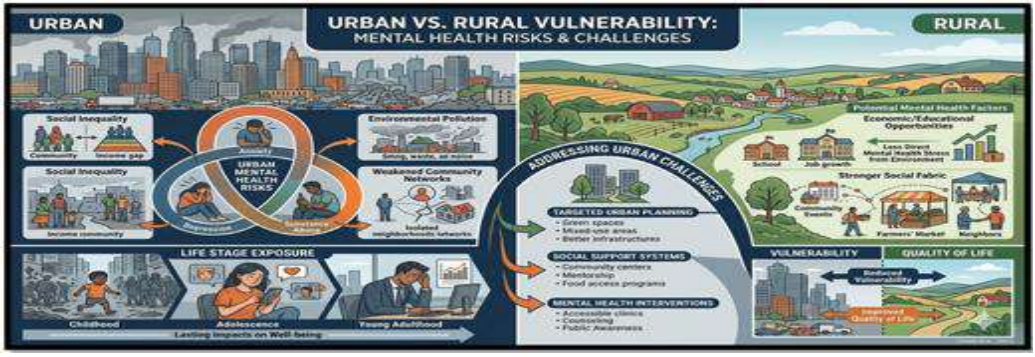

Figure 11.6: Urban vs. Rural Vulnerability

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6.2. Climate-Induced Resource Conflicts

Climate change is a significant driver of resource scarcity, particularly for water and arable land, which in turn deepens socio-economic inequality and fuels conflict. Studies from across Africa show how environmental scarcity and relative deprivation intensify tensions between groups such as farmers and herders, with these pressures often triggering displacement and instability, especially in regions like the Sahel and the Lake Chad Basin, where weak governance structures make the conflicts harder to contain. Addressing this requires integrated strategies spanning stronger governance, sustainable livelihoods, climate adaptation, and early warning systems (Osazuwa *et al*., 2025).

6.3. Integrated Resource Management

Integrated Water Resources Management (IWRM) stands out as a central approach for strengthening water governance and long-term sustainability. Comparative research shows that regions applying IWRM tend to manage resources markedly better, largely because effective water governance depends on coordination among stakeholders, adherence to sound governance principles, and efficient allocation of resources — findings that reinforce the value of integrated approaches for managing complex resource systems (Katusiime & Schütt, 2020).

7. Case Studies: Regional Climate Shocks

7.1. Floods in Pakistan (2022): Systemic Breakdown

The 2022 floods in Pakistan, triggered by extreme monsoon rainfall, rank among the most severe climate-related disasters in the country's history, although limitations in climate models and natural variability leave some uncertainty around their precise causes. Importantly, climatic factors alone cannot explain the scale of devastation: structural vulnerabilities, inadequate infrastructure, unplanned settlement in flood-prone areas, weak disaster management systems, poverty, and political instability, significantly amplified the impact. The disaster underscores the importance of integrating climate adaptation with socioeconomic policy and governance reform (Waseem & Rana, 2023).

Figure 11.7: Large-Scale Flooding in Rural and Urban Areas in Pakistan

7.2. Sub-Saharan Africa: Chronic Drought Systems

Drought has grown both more frequent and more severe across Sub-Saharan Africa, deepening the region's vulnerability. Evidence points to a clear worsening trend, bringing crop failures, water scarcity, food insecurity, and mounting economic pressure in its wake. The consequences extend well beyond environmental stress to social disruption, including migration, malnutrition, disease outbreaks, and family breakdown, and current adaptation efforts by governments and non-governmental organizations remain insufficient given the scale of the problem. Building durable resilience will require better drought preparedness, more sustainable resource management, and stronger policy frameworks (Wilhite, 2000).

7.3. South Asia Heatwaves: Yield Collapse Risk

Rising greenhouse gas emissions have substantially altered global temperature and precipitation patterns, and the scientific consensus, reflected in successive IPCC assessments, confirms a strong causal link between

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human activity and global warming. By the end of the twenty-first century, global surface temperatures could rise by 3–6°C alongside a 12–14% increase in rainfall (IPCC, 2018, 2022), changes that pose serious risks to agricultural productivity, particularly in South Asia, where extreme heatwaves threaten both crop yields and food security (Figure 11.8). Regional projections show substantial variation in temperature and precipitation across different parts of Africa as well, further illustrating how unevenly climate change is felt. Uncertainties remain, but the overall trend points toward growing risk of yield collapse under extreme climatic conditions (Knox *et al*., 2012; IPCC, 2018).

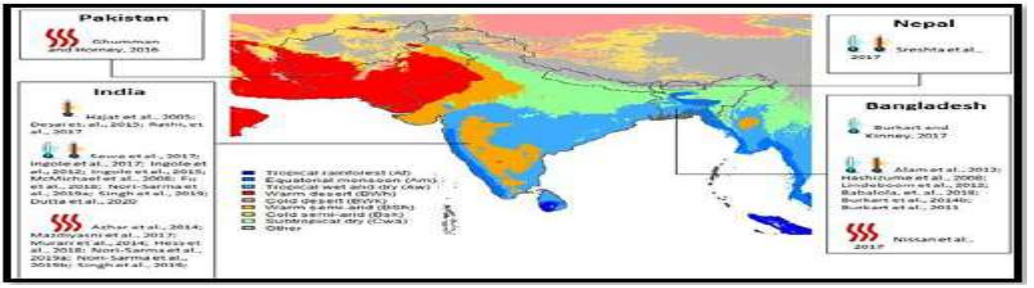

Figure 11.8: South Asian Climate Vulnerability Map

7.4. Global Supply Chain Disruptions

Global supply chains are growing more vulnerable to disruption from climate change, pandemics, technological shifts, and geopolitical instability. COVID-19 in particular showed how quickly shocks can propagate through interconnected systems, disrupting production, distribution, and consumption alike, and generating significant economic, social, and political fallout for businesses and societies. Research points to the value of identifying recurring disruption patterns and adopting advanced management tools, such as digital supply chain twins, to build resilience, flexibility, and stability, making supply chain strengthening a critical task for navigating an increasingly uncertain global environment (Ivanov & Dolgui, 2020).

8. Biotechnological Innovations in Crop Adaptation to Climate Change

8.1. CRISPR and Gene Editing Technologies

CRISPR–Cas genome editing has emerged as a powerful biotechnological tool for developing climate-resilient crops, allowing precise modification of genes linked to tolerance against both abiotic and biotic stresses (Figure 11.9).

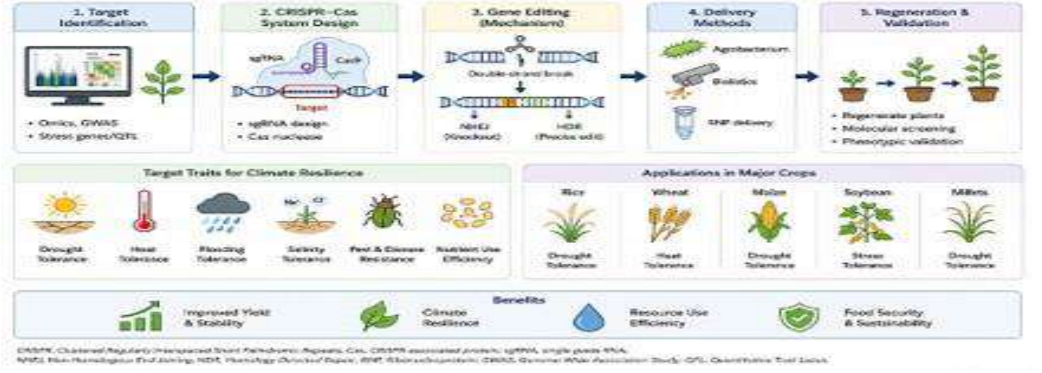

Figure 11.9: CRISPR and Gene Editing Technologies for the Development of Climate Resilient Crops

The process typically proceeds through target-gene identification, guide RNA (sgRNA) design, CRISPR–Cas-mediated editing, delivery of the editing machinery into plant cells, and regeneration of edited plants for

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phenotypic evaluation. It has been applied successfully to improve tolerance to drought, heat, salinity, flooding, and disease, as well as nutrient-use efficiency, in major crops including rice, wheat, maize, soybean, and millets. Relative to conventional breeding, CRISPR-based editing offers greater precision, shorter breeding cycles, and the option of producing transgene-free cultivars, which together accelerate crop improvement and strengthen agricultural productivity and food security under a changing climate (Chavhan *et al*., 2025; Chen *et al*., 2024; Kumar *et al*., 2023; Rai *et al*., 2023; Ceasar & Ignacimuthu, 2023; Yadav *et al*., 2023; Wang *et al*., 2022).

8.2. Contribution of PGPR, Mycorrhizae, And Nitrogen-Fixing Bacteria to Agriculture (Biofertilizers)

Beneficial soil microorganisms contribute substantially to plant health, soil fertility, and resilience against environmental stress. Plant Growth-Promoting Rhizobacteria (PGPR) boost nutrient uptake, stimulate root development, and improve tolerance to drought and salinity, while mycorrhizal fungi enhance water absorption, strengthen soil structure, and increase phosphorus availability. Nitrogen-fixing bacteria such as *Rhizobium* lessen dependence on synthetic nitrogen fertilizers by converting atmospheric nitrogen into forms plants can use. Collectively, these microbial innovations support sustainable agriculture while limiting environmental degradation (Chattaraj *et al*., 2025; Fasusi *et al*., 2023; Al-Turki *et al*., 2023; Sagar *et al*., 2021).

8.3. Biological Alternatives to Synthetic Agrochemicals in Sustainable Farming (Biopesticides)

Biopesticides, derived from natural sources such as bacteria, fungi, algae, and plant extracts, offer an environmentally safer alternative for pest and disease control. By reducing reliance on synthetic agrochemicals, they help limit soil and water pollution and support ecological balance, making them an essential component of climate-smart agriculture (Verma *et al*., 2024; Swapan *et al*., 2023; Sehrawat *et al*., 2021; Fenibo *et al*., 2022).

8.4. Sustainable Food Processing Through Fermentation Biotechnology

Fermentation is a valuable biotechnological tool for improving food preservation, nutritional quality, and food security. Microbial fermentation extends the shelf life of perishable products, cuts post-harvest losses, and improves digestibility and nutrient bioavailability, while fermented foods also support gut health and food safety by suppressing pathogenic microorganisms. In resource-limited settings without reliable refrigeration, fermentation offers a low-cost, sustainable way to preserve food quality and reduce waste (Vermelho *et al*., 2025; Nascimento & Barros, 2025; Aguirre-Garcia *et al*., 2024; Siddiqui *et al*., 2023).

9. Synthetic Biology in Food Systems and Key Applications

Synthetic biology is emerging as a powerful means of tackling global food security challenges by enabling the design of biological systems that produce sustainable, functional food products. Applications range from microbial “cell factories” that manufacture food components, additives, and nutrients to alternatives for conventional animal-based products such as meat, milk, and sweeteners (Figure 11.10). Recent progress in the field points to its potential to improve food safety, nutritional quality, and environmental sustainability, positioning synthetic biology as a critical tool for the food systems of the future (Lv *et al*., 2021).

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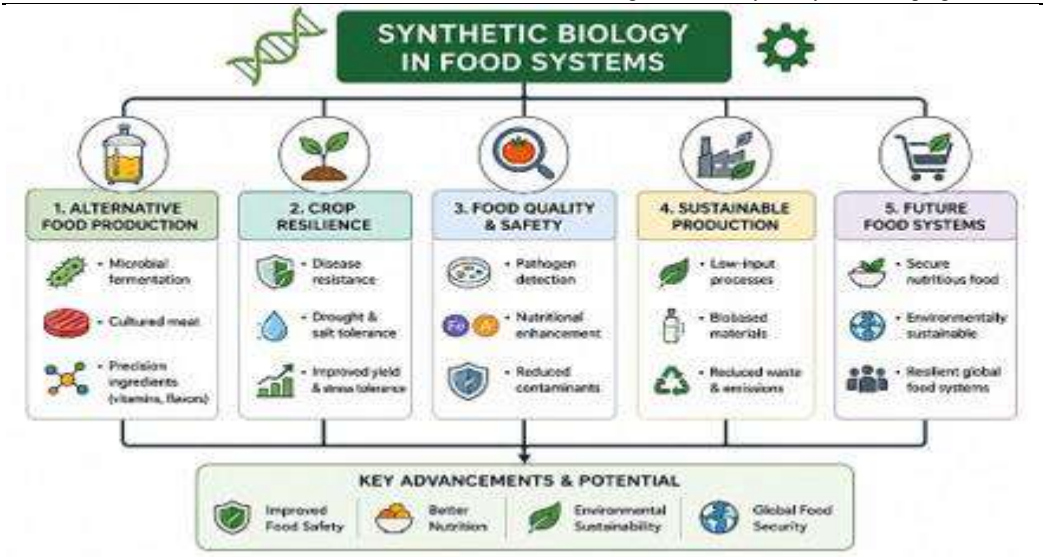

Figure 11.10: Synthetic Biology in Food Systems

9.1. Microbiome Engineering

Microbiome engineering seeks to modify microbial communities in ways that enhance their functional capabilities, but the complexity of microbial interactions and the limited availability of effective engineering tools make this a difficult undertaking. Recent studies propose combining top-down and bottom-up approaches to construct synthetic microbiomes with enhanced function.

For instance, natural microbiomes have been steered toward improved bioremediation performance through herbicide treatments combined with degrader inoculation. Computational tools such as SuperCC further support this work by enabling analysis of metabolic interactions and informing the design of synthetic microbial communities, offering a practical framework for future applications (Zhang *et al*., 2026).

9.2. Precision Fermentation and Food

Precision fermentation is an emerging cellular-agriculture technology that uses microorganisms to produce alternative proteins, directly addressing two major concerns with conventional food systems: environmental impact and animal welfare. Through optimized microbial strains and fermentation processes, it is now possible to produce animal-like proteins, including milk and egg proteins, and the approach holds considerable promise for advancing sustainable, scalable, and innovative food production (Knychala *et al*., 2024).

10. Climate-Smart Agriculture and AI

Climate change affects agriculture everywhere, but effective adaptation is inherently location-specific and needs to be validated at the smallholder level. Climate-smart agriculture (CSA) practices applied within integrated crop-livestock farming systems have been shown to raise both productivity and income (Bhatnagar *et al*., 2024).

10.1. Early Warning Systems

As climate change accelerates, societies face growing exposure to disaster and stress, underscoring the urgent need for effective early warning systems (EWS) that can monitor, assess, and communicate risk in support of resilience and sustainable development. Even so, challenges persist around hazard forecasting, risk communication, and decision-making (Rokhideh *et al*., 2025).

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10.2. Digital Agriculture and AI-Driven Innovations

Agriculture remains vital for economic growth, yet population growth, climate change, and resource constraints are making production increasingly challenging. Precision agriculture responds to this by combining machine learning (ML) and the Internet of Things (IoT) to improve efficiency and sustainability: ML models help predict soil conditions and crop yields and detect diseases and weeds, computer vision supports crop monitoring, and sensor-based analysis improves livestock health and behavior management. Smart systems for automated irrigation and harvesting further reduce labor requirements. Taken together, ML-driven farming raises productivity, quality, and sustainability (Sharma *et al*., 2021; AbdelRahman, 2023).

11. Policy Frameworks and Governance Systems

11.1. Climate Policy Integration Frameworks

Responding effectively to climate change requires strong policy coordination, an aim commonly pursued through policy integration. Environmental Policy Integration (EPI) has long been central to sustainable development efforts, but Climate Policy Integration (CPI) is a newer and increasingly important concept that, unlike EPI's broad integration, focuses on coordinating specific sectors toward targeted climate goals (Plank *et al*., 2021).

11.2. National-Level Policy Strategies

Environmental governance has traditionally relied on single-issue regimes with binding rules for states, yet major global challenges such as climate change, deforestation, and biodiversity loss are in practice governed through far more complex systems that combine legal and non-legal instruments and both governmental and non-governmental actors. Understanding their real impact therefore requires moving beyond simple measures of compliance and effectiveness toward a broader concept of influence over domestic policy and practice. One such framework identifies four pathways through which this influence operates: international rules, norms and discourse, market mechanisms, and direct access to domestic policymaking — together explaining how global actors shape national and firm-level action, with forest governance serving as a leading example (Bernstein & Cashore, 2012).

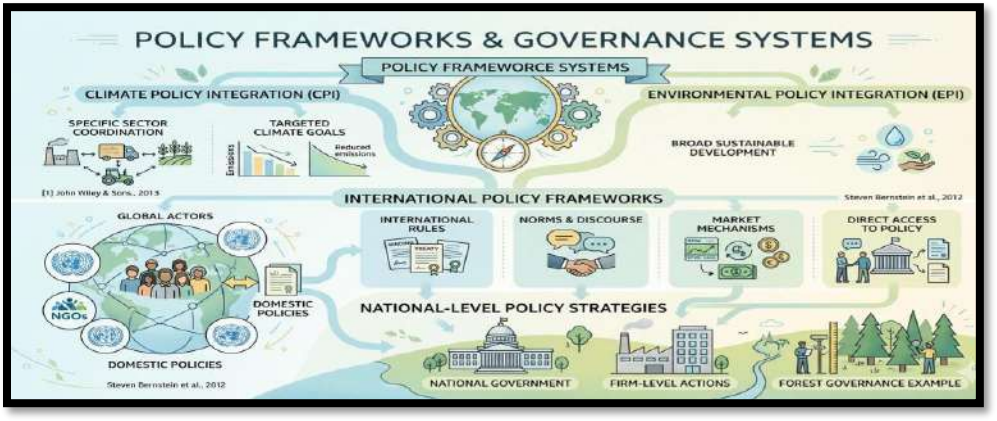

Figure 11.11: Policy Frameworks and Governance Systems

11.3. Government Policy

Government policies play a crucial role in strengthening resilience across food and agricultural systems (Akbar *et al*., 2025; Hogan & Schlenker, 2024; Bikomeye *et al*., 2021). They do so largely by setting the

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overall agenda for food security, disaster risk reduction, and climate adaptation at both national and subnational levels.

11.4. Community-Based Adaptation

People, their local cultures, and the environments they inhabit form complex, dynamic social-ecological systems that have co-evolved over time and remain continually shaped by a wide range of factors, including climate and other global changes (McMillen *et al*., 2017).

12. Future Perspectives on Transformative Food Systems

12.1. Climate-Resilient Functional Foods and Nutritional Innovation

Within modern agriculture and food science, emergent crops offer a promising route toward diversification, sustainability, and improved food security. Neglected and underutilized species (NUS) such as quinoa, amaranth, chia, moringa, and millets combine exceptional nutritional properties with strong adaptability to diverse environmental conditions, and their resilience to climate-related stress makes them valuable for sustainable agriculture, functional food development, and more diversified cropping systems. Wider adoption of these crops nonetheless remains constrained by limitations in production and processing technology, consumer awareness, and commercialization (Matías *et al*., 2024).

12.2. Dynamics of Transformational and Incremental Change

Transformational climate adaptation calls for fundamental changes in governance, institutions, and management practice in order to keep pace with the escalating impacts of climate change. Rather than treating incremental and transformational adaptation as opposing approaches, it is more useful to see how gradual, small-scale interventions can accumulate into substantial long-term transformation, achieved by scaling up successful local initiatives, integrating innovative practices, overcoming systemic barriers, and strengthening adaptive governance. This view emphasizes adaptive leadership, collaborative decision-making, and institutional flexibility as the building blocks of resilient, sustainable systems capable of responding to evolving climate challenges (Termeer *et al*., 2017).

12.3. Integrated Framework for Food System Resilience

Food system resilience is best understood as a multidimensional capacity, the ability of a food system to withstand, adapt to, and recover from environmental, economic, and social disturbances while still delivering food security and sustainability. Building this capacity means strengthening three complementary strategies: robustness to resist shocks, recovery to restore functionality once disrupted, and reorientation to adapt and transform as conditions change. Meeting these objectives requires balancing the priorities of diverse stakeholders, navigating trade-offs, and fostering inclusive governance and collaborative decision-making so that food systems remain equitable, adaptive, and future-ready (Zurek *et al*., 2022).

13. Conclusion

Climate change is fundamentally reshaping global food systems, deepening existing vulnerabilities and generating new challenges for food security, nutrition, and sustainable development. As this chapter has shown, climate-induced shocks — droughts, floods, heatwaves, soil salinity, and tropical cyclones among them — interact with socioeconomic inequality, fragile supply chains, and resource constraints to undermine the stability, availability, accessibility, and utilization of food. These impacts weigh most heavily on smallholder farmers, low-income populations, women, and communities in climate-sensitive, resource-scarce settings.

The evidence reviewed here makes clear that food system resilience cannot be achieved through isolated interventions; it demands an integrated, systems-based approach that links climate adaptation, sustainable resource management, technological innovation, and inclusive governance. Climate-smart agriculture, biotechnology, precision farming, artificial intelligence, early warning systems, and microbial and genetic innovation all offer promising ways to strengthen adaptive capacity and reduce vulnerability, but they need

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to be matched by investment in resilient infrastructure, water-energy-food nexus management, gender-responsive policy, and community-based adaptation that addresses the social dimensions of resilience.

Ultimately, building resilient food systems requires shifting from reactive crisis management toward proactive transformation. Governments, researchers, private sector actors, and local communities need to work together to develop policies and innovations that strengthen a food system's capacity to anticipate, absorb, adapt to, and recover from future shocks. Through integrated, evidence-driven, and inclusive approaches, societies can build food systems that are not only more resilient to climate change, but also more equitable, sustainable, and capable of securing adequate food and nutrition for present and future generations.

References

AbdelRahman, M. A. (2023). An overview of land degradation, desertification and sustainable land management using GIS and remote sensing applications. *Rendiconti Lincei. Scienze Fisiche e Naturali*, *34*(3), 767–808. https://doi.org/10.1007/s12210-023-01155-3

Afshin, A., Sur, P. J., Fay, K. A., Cornaby, L., Ferrara, G., Salama, J. S., ... Murray, C. J. (2019). Health effects of dietary risks in 195 countries, 1990–2017: A systematic analysis for the Global Burden of Disease Study 2017. *The Lancet*, *393*(10184), 1958–1972. https://doi.org/10.1016/S0140-6736(19)30041-8

Aguirre-Garcia, Y. L., Nery-Flores, S. D., Campos-Muzquiz, L. G., Flores-Gallegos, A. C., Palomo-Ligas, L., Ascacio-Valdés, J. A., Sepúlveda-Torres, L., & Rodríguez-Herrera, R. (2024). Lactic acid fermentation in the food industry and bio-preservation of food. *Fermentation*, *10*(3), 168. https://doi.org/10.3390/fermentation10030168

Ahammed, K. B., & Pandey, A. C. (2021). Characterization and impact assessment of super cyclonic storm AMPHAN in the Indian subcontinent through space borne observations. *Ocean & Coastal Management*, *205*, 105532. https://doi.org/10.1016/j.ocecoaman.2021.105532

Akbar, A., Darma, R., Irawan, A., Fudjaja, L., Amandaria, R., & Akzar, R. (2025). An institutional framework for enhanced food security amidst the COVID-19 pandemic: Strategic implementation and outcomes. *Journal of Agriculture and Food Research*, *21*, 101833. https://doi.org/10.1016/j.jafr.2025.101833

Al-Turki, A., Murali, M., Omar, A. F., Rehan, M., & Sayyed, R. Z. (2023). Recent advances in PGPR-mediated resilience toward interactive effects of drought and salt stress in plants. *Frontiers in Microbiology*, *14*, 1214845. https://doi.org/10.3389/fmicb.2023.1214845

Baumgartner, A., Pachnis, D., Parra, L., Hersberger, L., Bargetzi, A., Bargetzi, L., Kaegi-Braun, N., Tribolet, P., Gomes, F., Hoess, C., Pavlicek, V., Bilz, S., Sigrist, S., Braendle, M., Henzen, C., Thomann, R., Rutishauser, J., Aujesky, D., Rodondi, N., ... Schuetz, P. (2021). The impact of nutritional support on malnourished inpatients with aging-related vulnerability. *Nutrition*, *89*, 111279. https://doi.org/10.1016/j.nut.2021.111279

Bernstein, S., & Cashore, B. (2012). Complex global governance and domestic policies: Four pathways of influence. *International Affairs*, *88*(3), 585–604. https://doi.org/10.1111/j.1468-2346.2012.01090.x

Bhatnagar, S., Chaudhary, R., Sharma, S., Janjhua, Y., Thakur, P., Sharma, P., & Keprate, A. (2024). Exploring the dynamics of climate-smart agricultural practices for sustainable resilience in a changing climate. *Environmental and Sustainability Indicators*, *24*, 100535. https://doi.org/10.1016/j.indic.2024.100535

Bikomeye, J. C., Namin, S., Anyanwu, C., Rublee, C. S., Ferschinger, J., Leinbach, K., ... Beyer, K. M. (2021). Resilience and equity in a time of crises: Investing in public urban greenspace is now more essential than ever in the US and beyond. *International Journal of Environmental Research and Public Health*, *18*(16), 8420. https://doi.org/10.3390/ijerph18168420

Bourceret, A., Amblard, L., & Mathias, J. D. (2021). Governance in social-ecological agent-based models: A review. *Ecology & Society*, *26*(2). https://doi.org/10.5751/ES-12440-260238

Ceasar, S. A., & Ignacimuthu, S. (2023). CRISPR/Cas genome editing in plants: Dawn of Agrobacterium transformation for recalcitrant and transgene-free plants for future crop breeding. *Plant Physiology and Biochemistry*, *196*, 724–730. https://doi.org/10.1016/j.plaphy.2023.02.030

Chattaraj, S., Samantaray, A., Ganguly, A., *et al*. (2025). Employing plant growth-promoting rhizobacteria for abiotic stress mitigation in plants: With a focus on drought stress. *Discover Applied Sciences*, *7*, 68. https://doi.org/10.1007/s42452-025-06468-6

Chavhan, R. L., Jaybhaye, S. G., Hinge, V. R., Deshmukh, A. S., Shaikh, U. S., Jadhav, P. K., Kadam, U. S., & Hong, J. C. (2025). Emerging applications of gene editing technologies for the development of climate-resilient crops. *Frontiers in Genome Editing*, *7*, 1524767. https://doi.org/10.3389/fgeed.2025.1524767

Chen, F., Chen, L., Yan, Z., Xu, J., Feng, L., He, N., Guo, M., Zhao, J., Chen, Z., Chen, H., Yao, G., & Liu, C. (2024). Recent advances of CRISPR-based genome editing for enhancing staple crops. *Frontiers in Plant Science*, *15*, 1478398. https://doi.org/10.3389/fpls.2024.1478398

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Chrubasik-Hausmann, S., Hellwig, E., Müller, M., & Al-Ahmad, A. (2021). Antimicrobial photodynamic treatment with mother juices and their single compounds as photosensitizers. *Nutrients*, *13*(3), 710. https://doi.org/10.3390/nu13030710

Collins, P. Y., Sinha, M., Concepcion, T., *et al*. (2024). Making cities mental health friendly for adolescents and young adults. *Nature*, *627*, 137–148. https://doi.org/10.1038/s41586-023-07005-4

Corwin, D. L. (2021). Climate change impacts on soil salinity in agricultural areas. *European Journal of Soil Science*, *72*(2), 842–862. https://doi.org/10.1111/ejss.13010

Dai, A., Trenberth, K. E., & Qian, T. (2004). A global dataset of Palmer Drought Severity Index for 1870–2002: Relationship with soil moisture and effects of surface warming. *Journal of Hydrometeorology*, *5*(6), 1117–1130. https://journals.ametsoc.org/view/journals/hydr/5/6/jhm-386_1.pdf

Fasusi, O. A., Babalola, O. O., & Adejumo, T. O. (2023). Harnessing of plant growth-promoting rhizobacteria and arbuscular mycorrhizal fungi in agroecosystem sustainability. *CABI Agriculture and Bioscience*, *4*(1), 1–18. https://doi.org/10.1186/s43170-023-00168-0

Fenibo, E. O., Ijoma, G. N., & Matambo, T. (2022). Biopesticides in sustainable agriculture: Current status and future prospects. In *New and future development in biopesticide research: Biotechnological exploration* (pp. 1–53). https://www.preprints.org/frontend/manuscript/c78cfb3c4dfd658d353cfbe9f895788f/download_pub

Flint, L. E., Flint, A. L., Mendoza, J., Kalansky, J., & Ralph, F. M. (2018). Characterizing drought in California: New drought indices and scenario-testing in support of resource management. *Ecological Processes*, *7*(1), 1. https://doi.org/10.1186/s13717-017-0112-6

Food and Agriculture Organization. (2020). *The state of food security and nutrition in the world 2020*. https://openknowledge.fao.org/server/api/core/bitstreams/9a0fca06-5c5b-4bd5-89eb-5dbec0f27274/content

Heertje, I. (2013). Structure and function of food products: A review. *Food Structure*, *1*(1), 3–23. https://doi.org/10.1016/j.foostr.2013.06.001

Held, I. M., & Soden, B. J. (2000). Water vapor feedback and global warming. *Annual Review of Energy and the Environment*, *25*(1), 441–475. https://doi.org/10.1146/annurev.energy.25.1.441

Hodges, R. J., Buzby, J. C., & Bennett, B. (2011). Postharvest losses and waste in developed and less developed countries: Opportunities to improve resource use. *The Journal of Agricultural Science*, *149*(S1), 37–45. https://doi.org/10.1017/S0021859610000936

Hogan, D., & Schlenker, W. (2024). Empirical approaches to climate change impact quantification. In *Handbook of the economics of climate change* (Vol. 1, No. 1, pp. 53–111). North-Holland. https://doi.org/10.1016/bs.hesecc.2024.10.006

International Atomic Energy Agency. (2020). *Food systems and climate resilience technical meeting report*. https://www.iaea.org/sites/default/files/gc/gc65-5.pdf

Intergovernmental Panel on Climate Change. (2018). *Global warming of 1.5°C*. https://www.scirp.org/reference/referencespapers?referenceid=2956560

Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Impacts, adaptation and vulnerability*. Cambridge University Press. https://www.ipcc.ch/report/ar6/wg2/

Ivanov, D., & Dolgui, A. (2020). Viability of intertwined supply networks: Extending the supply chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak. *International Journal of Production Research*, *58*(10), 2904–2915. https://doi.org/10.1080/00207543.2020.1750727

Karl, T. R., & Trenberth, K. E. (2003). Modern global climate change. *Science*, *302*(5651), 1719–1723. https://doi.org/10.1126/science.1090228

Katusiime, J., & Schütt, B. (2020). Integrated water resources management approaches to improve water resources governance. *Water*, *12*(12), 3424. https://doi.org/10.3390/w12123424

Kiehl, J. T., & Trenberth, K. E. (1997). Earth's annual global mean energy budget. *Bulletin of the American Meteorological Society*, *78*(2), 197–208. https://doi.org/10.1175/1520-0477(1997)078<0197:EAGMEB>2.0.CO;2

Knox, J., Hess, T., Daccache, A., & Wheeler, T. (2012). Climate change impacts on crop productivity in Africa and South Asia. *Environmental Research Letters*, *7*(3), 034032. https://doi.org/10.1088/1748-9326/7/3/034032

Knychala, M. M., Boing, L. A., Ienczak, J. L., Trichez, D., & Stambuk, B. U. (2024). Precision fermentation as an alternative to animal protein, a review. *Fermentation*, *10*(6), 315. https://doi.org/10.3390/fermentation10060315

Kumar, M., Prusty, M. R., Pandey, M. K., Singh, P. K., Bohra, A., Guo, B., & Varshney, R. K. (2023). Application of CRISPR/Cas9-mediated gene editing for abiotic stress management in crop plants. *Frontiers in Plant Science*, *14*, 1157678. https://doi.org/10.3389/fpls.2023.1157678

Lv, X., Wu, Y., Gong, M., Deng, J., Gu, Y., Liu, Y., ... Chen, J. (2021). Synthetic biology for future food: Research progress and future directions. *Future Foods*, *3*, 100025. https://doi.org/10.1016/j.fufo.2021.100025

Machell, J., Prior, K., Allan, R., & Andresen, J. M. (2015). The water energy food nexus–challenges and emerging solutions. *Environmental Science: Water Research & Technology*, *1*(1), 15–16. https://doi.org/10.1039/C4EW90001D

© 2026 The Authors. Published under CC BY 4.0. | https://doi.org/10.66529/book.9786277945039.2026.ch11

Marx, W., Haunschild, R., & Bornmann, L. (2021). Heat waves: A hot topic in climate change research. *Theoretical and Applied Climatology*, *146*(1), 781–800. https://doi.org/10.1007/s00704-021-03758-y

Matías, J., Rodríguez, M. J., Carrillo-Vico, A., Casals, J., Fondevilla, S., Haros, C. M., ... Reguera, M. (2024). From "farm to fork": Exploring the potential of nutrient-rich and stress-resilient emergent crops for sustainable and healthy food in the Mediterranean region in the face of climate change challenges. *Plants*, *13*(14), 1914. https://doi.org/10.3390/plants13141914

McMillen, H., Ticktin, T., & Springer, H. K. (2017). The future is behind us: Traditional ecological knowledge and resilience over time on Hawai'i Island. *Regional Environmental Change*, *17*(2), 579–592. https://doi.org/10.1007/s10113-016-1032-1

Mohanavelu, A., Naganna, S. R., & Al-Ansari, N. (2021). Irrigation induced salinity and sodicity hazards on soil and groundwater: An overview of its causes, impacts and mitigation strategies. *Agriculture*, *11*(10), 983. https://doi.org/10.3390/agriculture11100983

Nascimento, A. P. S., & Barros, A. N. (2025). Sustainable innovations in food microbiology: Fermentation, biocontrol, and functional foods. *Foods*, *14*(13), 2320. https://doi.org/10.3390/foods14132320

Osazuwa, O. M. C., Oghogho, M. Y., Mboto, A. A., Onogwu, G. P., & Gogogwute, O. (2025). Climate change and civil conflict in Africa: Understanding the interconnections. *American Journal of Political Science Law and Criminology*, *7*(5), 158–174. https://doi.org/10.37547/tajpslc/Volume07Issue05-18

Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: Quantification and potential for change to 2050. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1554), 3065–3081. https://doi.org/10.1098/rstb.2010.0126

Pinchoff, J., Austrian, K., Rajshekhar, N., Abuya, T., Kangwana, B., Ochako, R., ... Ngo, T. D. (2021). Gendered economic, social and health effects of the COVID-19 pandemic and mitigation policies in Kenya: Evidence from a prospective cohort survey in Nairobi informal settlements. *BMJ Open*, *11*(3), e042749. https://doi.org/10.1136/bmjopen-2020-042749

Plank, C., Haas, W., Schreuer, A., Irshaid, J., Barben, D., & Görg, C. (2021). Climate policy integration viewed through the stakeholders' eyes: A co-production of knowledge in social-ecological transformation research. *Environmental Policy and Governance*, *31*(5), 387–399. https://doi.org/10.1002/eet.1938

Rai, G. K., Khanday, D. M., Kumar, P., Magotra, I., Choudhary, S. M., Kosser, R., Kalunke, R., Giordano, M., Corrado, G., Rouphael, Y., & Pandey, S. (2023). Enhancing crop resilience to drought stress through CRISPR-Cas9 genome editing. *Plants*, *12*(12), 2306. https://doi.org/10.3390/plants12122306

Rathore, S., Goyal, R., Jangir, B., Ummenhofer, C. C., Feng, M., & Mishra, M. (2022). Interactions between a marine heatwave and Tropical Cyclone Amphan in the Bay of Bengal in 2020. *Frontiers in Climate*, *4*, 861477. https://doi.org/10.3389/fclim.2022.861477

Rokhideh, M., Fearnley, C., & Budimir, M. (2025). Multi-hazard early warning systems in the Sendai framework for disaster risk reduction: Achievements, gaps, and future directions. *International Journal of Disaster Risk Science*, *16*(1), 103–116. https://doi.org/10.1007/s13753-025-00622-9

Sagar, A., Rathore, P., Ramteke, P. W., Ramakrishna, W., Reddy, M. S., & Pecoraro, L. (2021). Plant growth promoting rhizobacteria, arbuscular mycorrhizal fungi and their synergistic interactions to counteract the negative effects of saline soil on agriculture: Key macromolecules and mechanisms. *Microorganisms*, *9*(7), 1491. https://doi.org/10.3390/microorganisms9071491

Sehrawat, A., Sindhu, S. S., & Glick, B. R. (2021). Hydrogen cyanide production by soil bacteria: Biological control of pests and promotion of plant growth in sustainable agriculture. *Pedosphere*, *32*(1), 15–38. https://doi.org/10.1016/S1002-0160(21)60058-9

Sharma, A., Jain, A., Gupta, P., & Chowdary, V. (2021). Machine learning applications for precision agriculture: A comprehensive review. *IEEE Access*, *9*, 4843–4873. https://doi.org/10.1109/ACCESS.2020.3048415

Siddiqui, S. A., Erol, Z., Rugji, J., Taşçı, F., Kahraman, H. A., Toppi, V., Musa, L., Di Giacinto, G., Bahmid, N. A., Mehdizadeh, M., & Castro-Muñoz, R. (2023). An overview of fermentation in the food industry: Looking back from a new perspective. *Bioresources and Bioprocessing*, *10*, 85. https://doi.org/10.1186/s40643-023-00702-y

Starr, K. N. P., McDonald, S. R., & Bales, C. W. (2015). Nutritional vulnerability in older adults: A continuum of concerns. *Current Nutrition Reports*, *4*(2), 176–184. https://doi.org/10.1007/s13668-015-0118-6

Stavi, I., Thevs, N., & Priori, S. (2021). Soil salinity and sodicity in drylands: A review of causes, effects, monitoring, and restoration measures. *Frontiers in Environmental Science*, *9*, 712831. https://doi.org/10.3389/fenvs.2021.712831

Swapan, C., Mainak, B., Deewa, B., & Tanmoy, M. (2023). Natural pesticides for pest control in agricultural crops: An alternative and eco-friendly method. *Plant Science Today*. https://doi.org/10.14719/pst.2547

Termeer, C. J., Dewulf, A., & Biesbroek, G. R. (2017). Transformational change: Governance interventions for climate change adaptation from a continuous change perspective. *Journal of Environmental Planning and Management*, *60*(4), 558–576. https://doi.org/10.1080/09640568.2016.1168288

© 2026 The Authors. Published under CC BY 4.0. | https://doi.org/10.66529/book.9786277945039.2026.ch11

Tirado, M. C., Clarke, R., Jaykus, L. A., McQuatters-Gollop, A., & Frank, J. M. (2010). Climate change and food safety: A review. *Food Research International*, *43*(7), 1745–1765. https://doi.org/10.1016/j.foodres.2010.07.003

Trenberth, K. E., Fasullo, J., & Smith, L. (2005). Trends and variability in column-integrated atmospheric water vapor. *Climate Dynamics*, *24*(7), 741–758. https://doi.org/10.1007/s00382-005-0017-4

Ullrich, P. A., Xu, Z., Rhoades, A. M., Dettinger, M. D., Mount, J. F., Jones, A. D., & Vahmani, P. (2018). California's drought of the future: A midcentury recreation of the exceptional conditions of 2012–2017. *Earth's Future*, *6*(11), 1568–1587. https://doi.org/10.1029/2018EF001007

Verma, M. L., Kumar, A., Chintagunta, A. D., Samudrala, P. J. K., Bardin, M., & Lichtfouse, E. (2024). Microbial production of biopesticides for sustainable agriculture. *Sustainability*, *16*(17), 7496. https://doi.org/10.3390/su16177496

Vermelho, A. B., Cardoso, V. D. S., Domingos, L. T. S., Akamine, I. T., Amenu, B., Osei, B. K., & Neves Junior, A. (2025). Advancements in microbial applications for sustainable food production. *Foods*, *14*(19), 3427. https://doi.org/10.3390/foods14193427

Wang, Y., Zafar, N., Ali, Q., Manghwar, H., Wang, G., Yu, L., Ding, X., Ding, F., Hong, N., & Wang, G. (2022). CRISPR/Cas genome editing technologies for plant improvement against biotic and abiotic stresses: Advances, limitations, and future perspectives. *Cells*, *11*(23), 3928. https://doi.org/10.3390/cells11233928

Waseem, H. B., & Rana, I. A. (2023). Floods in Pakistan: A state-of-the-art review. *Natural Hazards Research*, *3*(3), 359–373. https://doi.org/10.1016/j.nhres.2023.06.005

Wheeler, T., & von Braun, J. (2013). Climate change impacts on global food security. *Science*, *341*(6145), 508–513. https://doi.org/10.1126/science.1239402

Wiers, R. W., Marroun, H. E., Bockting, C., & Krugers, H. (2025). Debate: Urban versus rural environments—Which is better for mental health? The one good thing about a small town. *Child and Adolescent Mental Health*, *30*(2), 189–191. https://doi.org/10.1111/camh.12771

Wilhite, D. A. (2000). *Drought: A global assessment* (Vols. 1–2). Routledge. https://www.scirp.org/reference/referencespapers?referenceid=202287

World Bank. (2021). *Food security and climate vulnerability report*. https://www.worldbank.org/en/topic/agriculture/brief/food-security-update

World Health Organization. (2021). *Malnutrition fact sheets*. https://www.who.int/news-room/fact-sheets/detail/malnutrition

Yadav, R. K., Tripathi, M. K., Tiwari, S., Tripathi, N., Asati, R., Chauhan, S., Tiwari, P. N., & Payasi, D. K. (2023). Genome editing and improvement of abiotic stress tolerance in crop plants. *Life*, *13*(7), 1456. https://doi.org/10.3390/life13071456

Zhang, Y., Jing, M., Lyu, L., Nie, L., Xu, X., Sun, R., ... Chu, H. (2026). Principles for rigorous design and application of synthetic microbial communities. *Advanced Science*, *13*(10), e14750. https://doi.org/10.1002/advs.202514750

Zurek, M., Ingram, J., Sanderson Bellamy, A., Goold, C., Lyon, C., Alexander, P., ... Withers, P. J. (2022). Food system resilience: Concepts, issues, and challenges. *Annual Review of Environment and Resources*, *47*(1), 511–534. https://doi.org/10.1146/annurev-environ-112320-050744

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CHAPTER 12

Adaptive Food Security Policies under Climate Uncertainty

Rehana Ali Naqvi[1,*], Sania Shaheen[1] & Irfan Hussain Khan[2]
[1]Department of Economics, University of Wah, Pakistan
[2]Department of Economics, Government College University Faisalabad, Pakistan
Corresponding author's email: rehana.naqvi@uow.edu.pk

Abstract

Global food security is facing a greater level of uncertainty because of climate change, which has outpaced the challenges of static food security policies. This chapter discusses the importance of adaptive strategies and policies for food security in the face of dynamic climate, economic, and institutional risks. It discusses the impacts of climate variability on food availability, access, utilization and stability, especially in areas of vulnerability. The chapter defines adaptive policies for food security as an agile, learning process that should be based on decision-making under deep uncertainty. It explores methods like scenario analysis, robust decision-making, and triggers, and how real-time data, early warning systems, and artificial intelligence can enhance policy responsiveness. Governance and policy agility, decentralization, and stakeholder coordination are highlighted. It discusses policy mechanisms such as dynamic food stocks, flexible subsidies, climate-indexed insurance and adaptive social safety nets to build resilience. Despite practical challenges, such as limited data and financial resources, the chapter highlights the need for a shift towards anticipatory, technology-informed governance to achieve sustainable, resilient food security under climate change.

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1. Introduction

One of the most crucial global development issues in the period of increasing pace of climate change has become food security. Although important strides were achieved to alleviate hunger in the beginning of the 21st century, recent global shocks such as climate extremes, geopolitical instabilities and disruptions in supply chains have undone much of these achievements. In an investigation published by the Food and Agriculture Organization (FAO), almost 735 million individuals were at risk of hunger in 2023, and climate variability is recognized as a main factor in the aggravation of food insecurity, especially in susceptible areas of Asia and Africa (FAO, 2023a). Simultaneously, the Intergovernmental panel on climate change (IPCC) emphasizes the fact that the frequency and intensity of extreme weather events are directly affecting agricultural output, destabilizing food systems, and output prices, which fluctuate increasingly (IPCC, 2022).

Here, conventional food security policies- which have generally been structured as long-term planning tools, are becoming inadequate. Such methods usually presuppose more predictable climatic and economic situations, modest uncertainty, and supply-demand relations. The modern food system, however, functions within profound uncertainty where the impacts resulting in climate change are not linear, shocks are cascading, and global risks are interconnected. Consequently, less flexible policy structures are becoming less responsive to quick and unforeseeable food supply, demand, consumption, and stability.

This has triggered an emerging policy and scholarly agreement on the necessity of adaptive food security governance that focuses on dexterity, learning, and responsiveness of institutions. Adaptive policies are dynamic rather than firm solutions and adapt as time goes by depending on new information, feedback loop and the shifting risk landscape. According to the World Bank (2025), resilience in food systems is not just a concern of preventing risks but also the ability to anticipate, absorb and adapt to shocks without compromising the fundamental functionality of the entire system.

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The basic premise of adaptive food security policies is that decisions need to be made in circumstances where there is missing and frequently distorted information. Climate uncertainty poses profound problems in agricultural production projections, food reserves, and social protection schemes. So, the contemporary policy frameworks are becoming more dependent on the scenario planning, early warning systems, and real-time data analytics, to facilitate even more flexible decision structures (OECD, 2023). These policies enable policymakers to stop managing crises reactively and instead have a proactive and anticipatory governance.

Integration of learning systems within the governance structures is one more essential aspect of adaptive food security policy. In contrast to traditional top-down policy-making systems, learning based systems inherently receive performance feedback on the implementation processes to keep refining the strategies. This will cover the use of online farming instruments, remote sensing, and Artificial Intelligence-grounded forecasting models in enhancing decision precision and promptness (FAO, 2023b). These systems build institutional memory and strengthen the ability of governments to respond to both the slow-onset climate changes and to shocks.

Institutional flexibility has also implications for adaptive food security. Rigid institutions tend to delay the response to the crisis, exacerbating food crises and food reduction inefficiency. But agile institutions decentralize decision making, foster inter-sectoral co-operation and have the capacity to mobilize resources. This is not limited to technical solutions and drives institutional changes to strengthen fluidity, transparency and co-ordination.

This call to arms is growing yet there is low operationalization of the adaptive food security policies in developing countries. Operationalization is still not achieved because of structural barriers such as lack of data, finance and political economy factors. Moreover, equity needs to be considered as the adaptive mechanisms may harm marginalized groups, if not inclusive.

This chapter thus seeks to comprehensively and analytically explore adaptive food security policies in an uncertain climate. It looks at three key inter-linked components of (i) decision-making under uncertainty, (ii) a learning system to adapt policies and (iii) flexible governance. The chapter adds to the current discourse about how to make the food system more adaptive, flexible and equitable in the uncertain future of increasingly variable climate change.

2. Climate Uncertainty and Food System Vulnerability

The unpredictability of climate has completely changed the risk landscape of global food systems, introducing non-linear, complicated, and unpredictable risk dynamics that make it harder to plan for agriculture and policy in the usual ways. In contrast to historical climate variability, present-day trends are defined by rising frequency, severity and concomitancy of extreme weather events - such as droughts, floods, heatwaves, and random precautions. Not only are the changes more severe, but they are also less predictable, and policymakers and producers face challenges in using historical trends as a guide towards making future decisions (IPCC, 2022).

At its heart, this challenge is defined by the notion of deep uncertainty, where the likelihoods of future outcomes lack knowledge or are vied strongly. Within the food systems framework, such uncertainty impacts on several layers at once such as crop yields and water availability, global trade flows and food prices. An instance of this is that with increasing temperatures and changing rainfall regime, agricultural productivity is taken directly hit, especially of staple crops like wheat, rice, and maize. Research claims that if temperature rises by 1 °C, the yield of major crops might fall by 3-7 percent, and the effects will be disproportionately large in tropical and semi-arid areas (Zhao *et al*., 2017; IPCC, 2022).

In addition to production, climate uncertainty also has an impact of disrupting food supply chains, increasing vulnerabilities within the entire system. Dramatic weather conditions may destroy infrastructure, slow transportation, and make the post-harvest loss. Such shocks were especially pronounced in the recent climate-induced shocks, whereby the localized production shocks spread to the overall market instabilities. With increasing food systems integration and interconnectedness, these shocks are no longer regionalized

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but can easily spread among international markets, leading to price volatility and reasons to access food (FAO, 2023b).

The concept of food security is often interpreted in four dimensions; availability, access, utilization, and stability. Climate uncertainty has a different impact on each of these dimensions, which are interrelated. Firstly, availability is directly at risk with falling agricultural productivity and high risks of crop failure. Second, access is compromised by increasing the price of food and unstable income, especially among low-income families. Third, the ability to use is influenced by lower nutritional content of crops because of stressors in climate that can reduce protein and micronutrient levels, such as high CO_2 levels. Lastly, stability, or the possibility of having stable, long-term access to food, is being undermined by frequent climate shocks and market volatility (Myers *et al*., 2014; FAO, 2023b).

The exposure of food systems is not uniform. The developing world, especially south Asian and Sub-Saharan Africa region, are at greater risk as they are dependent on climate-sensitive crops, with low adaptive potential and structural socioeconomic factors. In a nation, such as Pakistan, where farming is a major source of livelihood and GDP, unpredictable monsoon weather, the melting of glaciers, and rising temperatures are extreme threats to the rural earnings and national food security. Examples of such catastrophic floods that in 2022 have caused massive crop losses, created interruptive food chains, and increased food inflation, point to the overall vulnerability of the food sector to climate stress (World Bank, 2023).

The socioeconomic and institutional factors, besides the biophysical risks, lead to the vulnerability of the food system. Lack of infrastructure with sufficient capacities of storage and market mechanisms can magnify the impacts of climate shocks. And overly restrictive policies and organizations with relatively longer response time make quick responses more difficult, which exacerbate negative impacts of intervention in vulnerable groups. Inequality is a big issue as marginal groups, small farmers, informal economy and women have limited access to resources, market information and technologies towards adaptation. These groups are being affected more because of climate change.

Risk cascades are another problem that is increasing. Climate shocks are occurring at the same time as other shocks, such as war, pandemics and economic shocks. This creates multi-currency. For instance, drought, high oil prices and export bans can occur simultaneously, which can reduce production, increase the cost of transporting food, and make it more difficult to import food, contributing to a significant food scarcity. These risks are inter-connected and have no place for previous "silos" policy. These risks require a whole system response (OECD, 2023).

At the same time, the uncertainty that climate change brings about also entails considerable volatility in international markets. Measures such as export bans, hoarding and speculation may be driving the prices up and down during the supply shock events. While also being a major threat to national food security, such fluctuations have macroeconomic impacts (such as inflation and fiscal instability in the food importing countries). This underlines a need for dynamic policymaking that will be able to respond to the domestic and global shock in a dynamic way.

In a nutshell, food systems are becoming a highly dynamic risk-driven phenomenon due to climatic uncertainty. The multidimensionality of vulnerability (across biologically based, economical and institutional sequences) challenges the way that we need to shift from the reflexive and non-responsive policy interventions to the more flexible and resilient ones. Such understanding of these vulnerabilities is the very first step in designing policies that will triumph over uncertainty and risk and promote sustainable food security in the increasingly uncertain climate.

3. Conceptualizing Adaptive Food Security Policy

Adaptive food security policy is a shift away from singular policy systems to the adaptive policy system that can thrive under conditions of uncertainty. Past food security policies have been mostly designed with the presumption of stable climate and economic conditions, and underpinned by certain target, long-term projections and linear programming. However, with increasing climate variability and occurrence of

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systemic risks, such responses are failing. In contrast, the adaptive food security policy framework is designed to be flexible with respect to new knowledge, new risks, as well as dynamic adaptation to interventions in order to enhance resilience of food systems in the long term (Hallegatte, 2009).

The adaptive food security policy is underpinned by flexibility, robustness and iterative learning. Flexibility is related to the fact that policies may be adjusted when there are changes in environmental and socioeconomic conditions; whereas robustness means policies are relatively well performing in a wide range of uncertain events. A characteristic feature is the process of iterative learning, i.e. ongoing monitoring and evaluation, and revision of policies, by gathering up-to-date information and feedback. This can be integrated with the concept of adaptive management, which implies that policies are experiments that are developed through an iterative process of implementation, evaluation and revision (Armitage *et al*., 2008; OECD, 2023).

An important difference in the field of adaptive policy design lies in the difference between a fail-safe and a safe-to-fail system. Fail-safe strategies seek to avoid system failure when defined conditions are satisfied but, in many cases, the measure involved is hard and resource-consuming and is unlikely to be correct when things get extreme or unanticipated. Contrary to this, safe-to-fail systems embrace failure that failure is unavoidable in complex and uncertain settings and, in fact, aim at minimizing the impact of such a failure and to recover promptly. When applied in a food security context, this may include diversifying their food supply stream, decentralizing their storage, and having scalable safety nets that could be increased under crises. This change corresponds with a wider policy of transition to resilience thinking.

The next significant aspect of adaptive food security policy is that it must be based on the idea of decision making under deep uncertainty, where it is impossible to estimate probabilities of the future outcomes reliably. Such tools like scenario planning, robust decision-making (RDM), and dynamic adaptive policy paths (DAPP) are becoming more popular among the policymakers. Such methods allow identifying policy alternatives that will hold up in a variety of plausible futures, as opposed to algorithms maximizing a single predicted outcome. Adaptive pathways can help policymakers to set up flexible policies with predetermined triggers or thresholds, which will alert to the need to modify the policy, which would help to minimize the likelihood of proving inappropriate or slow in response (Haasnoot *et al*., 2013; Webber & Samaras, 2022).

Lastly, adaptive food security policy is multi-scalar and integrative by nature and necessitates coordination at the local, national, and international levels of government. Food systems are intricate systems that encompass agricultural production, trade, infrastructure, and social protection processes. In this regard, various sectors and actors, such as farmers, governments, private actors, and international organizations, should be incorporated into adaptive policies. This also requires institutional settings that facilitate information exchange, decentralization in decision-making and quick policy coordination. Notably, any adaptive framework should consider the issues of equity as its central part with vulnerable populations not being left outside adaptive benefits but rather given priority to build their resilience. Adaptive food security frameworks provide a better way forward in managing the uncertainties associated with a changing climate by incorporating flexibility, learning and inclusivity in policy design.

4. Decision-Making Under Incomplete Information

The underlying information is incomplete, imperfect and frequently changing and on this basis, the decision-making process in the context of food security in the conditions of climate uncertainty is constrained. Compared to traditional policy settings, where probabilities are estimable, and outcomes are predictable with some reasonable degree of accuracy, the risks associated with climate alter the innermost uncertainty, with the probability and the extent of a future event being unknown. This poses a big problem for policymakers who must provide stable food systems since they must make decisions based on incomplete information on future climatic conditions, production results or market reactions. Consequently, once depending on accurate forecasts, traditional optimization-based models are now getting substituted with those that focus on robustness, flexibility, and adaptability (Webber & Samaras, 2022; IPCC, 2022).

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A common strategy in these settings is scenario-based planning, including modeling various plausible future scenarios depending on varied climate, economic, policy paths. Instead of trying to determine one outcome, scenario planning can allow policymakers to study a set of possible scenarios and evaluate an array of policy choices according to their performance in different circumstances. In food security planning this can entail such events as extreme droughts, trade breaks or fast-timed inflation of food. Stress-testing of policies on such situations helps decision-makers to discover policies that are less prone to uncertainty and more likely to sustain the stability of the system in question (OECD, 2023).

Developing on this, Robust Decision-Making (RDM) has become an influential analytical tool used to deal with uncertainty in complex systems. RDM does not aim at maximizing decisions under a most likely future scenario but rather finding policies with satisfactorily performance in a broad region of any challenge scenario. It is applied on simulation models and big datasets to test the responsiveness of various strategies to different situations and allow policy makers not to make such decisions that lead to failures under unforeseen conditions. RDM can be applied to inform policy formulation around food security by developing policies including flexible importation strategies, diversified patterns of farming, as well as adaptive safety nets that continue to be effective despite very differing climatic and market changes (Webber & Samaras, 2022).

Real options analysis is another crucial instrument, that gives flexibility in policy development by providing an option to make changes or postpone actions when new information appears. The strategy would be especially applicable in the case of agricultural infrastructure investment, irrigation schemes and food warehouses where future uncertainties will have to be made under long-term commitment. Real options thinking allows policymakers to phase investments, increase interventions step by step or reformulate plans following climate trends and system reactions. This diminishes chances of irreversible or maladaptive decisions and increases resilience of overall food systems (Hallegatte, 2009).

Moreover, threshold- or trigger-based policy mechanisms also play a key role in the implementation process of decision-making under uncertainty. They can be either through setting up certain indicators, such as rainfall, crop production or food price indices as triggers of policy action. For example, a certain level of decrease in rainfall can trigger the autopilot of launching of drought package measures, release of food stocks or expansion of social protection programs. Such systems would aim to remove policy delays and time lags as well as emergency interventions due to political lethargy and inaction. Trigger policies can enhance responsiveness and effectiveness of food security governance when combined with early warning systems and real-time data collection and analytics (FAO, 2023b).

Finally, recent advances in data-driven and AI-oriented decision-making systems are also significantly facilitating the management of partial information in food policy. Such techniques as machine learning, remote sensing and climate forecasting algorithms are starting to be more common to generate real-time information on crop condition, weather and market analysis data. These technologies facilitate more informed and adaptive decision-making by continually revising risk tests and policy options, with new data being available. They are, however, useful to the degree of the quality of data, institutional capabilities, and governing structures that are transparent and inclusive. The introduction of these tools into wider adaptive policy systems is a treatment with a future potential to enhance the process of decision-making in times of uncertainty, particularly in the developing world where other data systems may lack.

5. Learning Systems in Food Security Governance

Adaptive food security policies operationalized through learning systems facilitate the steady enhancement of decision-making regarding the operation in dynamic and uncertain conditions. In contrast to conventional models of governance that involve classical evaluations of policies and infrequent changes to existing ones, learning-based systems incorporate feedback loop policies into real time. Such systems operate in repeated cycles of monitoring, evaluation and changes so the policies-makers can modify the interventions depending on the results and the risks that arise. The method is especially vital to the food systems when the climate variability, market changes, and socio-political shocks demand a continuous adjustment of approaches (Armitage *et al*., 2008; FAO, 2023a).

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The main idea underlying learning systems entails adaptive management encompassing a set of approaches to policies as experiments, instead of solutions. In such modelling, policy interventions are put in place with the thought that they are to be updated as new information develops. An example of this is the adjustment of agriculture support programs seasonally which is informed by performance data, weather predictions, and farmer feedback. It is an iterative process that improves the effectiveness of policies over the long term and minimizes their threats of strict strategies that are one-size-fits-all. Notably, institutional learning is also facilitated by adaptive management that allows capturing the lessons of successes and failures in a specific way (OECD, 2023).

One of the enablers of such systems is incorporation of early warning and monitoring systems. Early warning systems that are informed by climatic conditions integrate meteorological data, satellite images and ground-based observations to deliver information in real time about climatic conditions that pose threats to food production such as droughts, floods, and outbreaks of pests among others. On the same note, food price monitoring systems do the same by monitoring the trends in the market and pointing out anomaly which could be an indication of new food crisis. These systems enable governments to be proactive instead of reactive, mitigating the gravity of the food insecurity responses when linked to triggers being induced by policy and other factors. The effectiveness of such solutions is seen in such global endeavors as the Famine Early Warning Systems Network (FEWS NET) that aims at enhancing preparedness and response (FAO, 2023a).

Recent developments in artificial intelligence (AI) and machine learning (ML) have improved the functions of learning systems in the field of governance in food security. Large amounts of climate, agricultural, and socioeconomic data can now be analyzed with predictive models to provide sound predictions of food demand, crop yields, and weather patterns. Some of the techniques like Dynamic Bayesian Networks (DBNs) and the reinforcement learning have found their way in complex, interdependent system modeling with uncertain condition. The tools allow policymakers to model the various scenarios, update predictions in real time, and optimize policy responses dependent on changing circumstances. Indicatively, AI-based systems can suggest food distribution changes or import regulations due to forecasted shortages in supply.

The other pivotal aspect of learning systems is how to instigate institutional feedback loops and knowledge-sharing systems. Good governance does not only involve data gathering but also systems that will translate the data into actionable knowledge. This involves the synchronization of agencies, consultation of stakeholders as well as utilizing online platforms to share information amongst various levels of governance. It is important to note that local knowledge (especially that of farmers and community organizations) contributes significantly to the richness of formal data systems and the relevancy of policy. Learning systems enhance the responsiveness and inclusivity of food security policies, in general, by enabling collaboration and information exchange (Armitage *et al*., 2008).

6. Institutional Agility and Governance Structures

Institutional agility is critical for the success of food systems in adapting to climate uncertainties and shocks. Nowadays, technological and analytical technologies are becoming increasingly available, but their application can be restricted by sluggish governance approaches that are slow to respond, sectorally disconnected, and unresponsive. Traditional institutions of food security policymaking and management are hierarchical, have inflexible mandates and procedural rules, which can delay actions in emergencies. In contrast, flexible institutions operate in an uncertain context to enable rapid decision-making, fluid resource allocation and continuous communication between multiple actors and levels of governance (World Bank, 2025; OECD, 2023).

Adaptive governance is a vital aspect of institutional agility, emphasizing decentralization, inclusion and iterative decision-making. Local governance arrangements give local governments autonomy to respond to local challenges, for instance localized drought or disrupted food supply chains. Local governments, such as state or district, can adopt policies to respond to local supply and demand for food products, provide localized food security mechanisms, or localized agricultural support. But there is also a need for national coordination to ensure policy coherence, resource mobilization and coordination of activities to national development

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plans. So, the balance between decentralization and strategic central control is important to establish flexible governance arrangements (Armitage *et al*., 2008).

Next is sectoral coordination, since food security and the relevant sectors - agriculture, water, energy, trade, health and social protection - are interconnected. Climate change can have flows-on effects to these sectors, such as a lack of water affecting food production, which then in turn affects food prices and nutrition. Agile modes of governance facilitate coordinated decision-making through "cross-cutting" decision-making processes and effective collaboration between policy and implementation agencies. An integrated approach to food systems' risk, involving inter-ministerial task forces, information systems and policy platforms is required (FAO, 2023a).

Public-private partnerships and multi-stakeholder approaches are also becoming more important for improving institutional agility. Agribusiness, logistics and technology companies are key players in the food supply chain and the innovation ecosystem. Their participation in policy development and implementation can enhance efficiency, provide resource access, and drive technology uptake. Likewise, civil society groups and community organizations provide important local insights and can assist with the implementation of specific programs. Multistakeholder governance approaches that include these actors are more likely to adapt to complex and changing issues in food systems (OECD, 2023).

Agile institutions also require the ability to mobilize resources and provide flexible funding. Climate-related food crises often call for urgent financial interventions, such as expanding social protection schemes, providing subsidies for staple food, or assisting farmers. But inflexible budgeting and scarce resources can limit these in developing nations. Alternative financing approaches, such as contingency funds, climate risk insurance and flexible budgeting processes, can increase government capacity to respond effectively to risks. They also enable proactive measures, enabling resources to be mobilized prior to crises (World Bank, 2025).

While critical, institutional agility is difficult to achieve because of political economy factors, capacity gaps and governance issues. Lack of coordination and conflicting policy priorities can also impede reforms to enhance agility. In developing countries, such as those in South Asia, institutional overlaps and weak administrative capacity can add to implementation challenges. To overcome these barriers, holistic governance reforms, institutional capacity strengthening, and the establishment of mechanisms for transparency and accountability are needed. In short, enhancing institutional agility is critical to converting ideas of adaptive policy into tangible, scalable and equitable solutions to food security in a changing climate.

7. Policy Tools to Adaptive Food Security

The traditional policy frameworks of stability are often scarce in the face of growing climate variability and uncertainty to provide stable food systems. Adaptive food security policies need responsive, adaptive, and learning-oriented tools that could adapt to the changing climatic, economic, and market changes. These tools focus on institutional agility, risk management and real-time information systems (IPCC, 2022; FAO, 2016). This section presents some of the main policy instruments, which contribute to resilience in food systems because they allow governments to effectively respond to shocks without compromising the long-term sustainability.

7.1. Flexible Price Stabilization and Subsidies

The price stabilization systems and flexible subsidies are vital in protection the consumer and the producer against the fluctuating food prices and disruption of supply, caused by climate changes. In contrast to fixed subsidy programs, adaptive subsidy systems vary with the fluctuating costs of production, market prices and the environment (FAO, 2022a). The mechanisms are used to ensure that food commodities such as essentials are affordable, and farmers have satisfactory incentives to continue farming.

Policies to stabilize prices can be in the form of variable input subsidies, targeted consumer subsidies and temporary price ceilings or floors because of predetermined levels. Digital monitoring systems and early warning measures like, rainfall abnormalities, crop yields, and price changes that are available in the market

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can help governments automatically to change the level of subsidies (Anderson & Nelgen, 2012). This responsiveness decreases fiscal inefficiency and enhances policy effectiveness in uncertain conditions.

In addition, the flexible subsidies will promote climate-resilient agricultural activities by basing financial incentives on sustainable actions, including water conservation, crop diversification, and uptake of drought resistant seed varieties (FAO, 2010). By doing so, subsidy programs can transform into temporary relief mechanisms to long-term resilience-building programs.

7.2. Dynamic Stock Management and Strategic Food Reserves

Strategic food reserves are important as a buffer to supply shocks due to droughts, floods, pests and market disruptions in the global market. Nonetheless, conventional reserve systems tend to be based on stock quantities and support strict distribution policies, which are unlikely to react effectively to changing conditions that evolve quickly. The adaptive food security policies thus focus on dynamic management of stocks that include real-time information and forecasting algorithms (FAO, 2001).

Dynamic stock management is a process that adjusts the procurement, stockholding and release decisions whenever production trends, consumption trends, and weather forecasts are tracked continuously. As an example, when there are good harvest time governments can buy more grain and when it is scarce, they can sell the stocks to stabilize prices and avoid shortages of food (FAO, 2016).

Additionally, well-managed food reserves help to increase supply stability, increase confidence in the market and decrease panic price spikes. Incorporation of modern technologies, including satellite-based crop surveillance systems, electronic inventory systems, and climate prediction models can greatly enhance efficiency and transparency of reserve management systems.

7.3. Climate-Indexed Insurance Schemes

Climate-indexed insurance plans are a new financial tool that allows insuring farmers against harm caused by climate changes without having to carry out complicated damage evaluation. These plans tie insurance claims to objective environmental measures, like the amount of rainfall, high or low temperatures, or a drought index. Payments are automatically disbursed when predetermined thresholds are met and they offer affected farmers the necessary support in form of money in time (Barnett *et al*., 2008).

This type of insurance program lowers the volatility of incomes, promotes investment in production inputs, and improves the ability of farmers to recuperate aftershocks. Notably, climate-indexed insurance also reduces the administrative expenses and eliminates the controversy on compensation, which makes it especially appropriate to regions with low institutional capacity (IPCC, 2022).

Governments can enhance the efficacy of climate-indexed insurance by incorporating it in the wider risk management areas, such as early warning systems, extension services and disaster preparedness programs (FAO, 2010). Public- private alliances are usually necessary in the expansion of the coverage and financial viability of these schemes (World Bank, 2023).

7.4 Trade Policies That are Adaptive

International trade is also crucial in domestic food stabilization in the event of local production due to climate shocks. Adaptive trade policies allow governments to react swiftly to either supply deficits or surpluses by adjusting rapidly in import tariffs, export restrictions and trade quotas (Martin & Anderson, 2012; WTO, 2021). The policies also contribute to stability of the market, as well as protecting national food security goals.

An example is the temporary lowering of tariffs on imported goods which can be used to bring in the necessary food commodities on a large scale in case of a drought and export restrictions which can be used to keep the staple foods in the country at a reasonable level in case of domestic food shortages (Anderson & Nelgen, 2012). These measures should however be properly planned to prevent unwanted market distortion or derailment of international trade relations.

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To make sure that adaptive trade policies are effective and credible, it is necessary to make sure that they are transparent, coordinated with regional trade partners, and that they comply with international trade agreements (WTO, 2021). Moreover, the timing and accuracy of trade interventions can be enhanced by employing data-driven decision-making frameworks, i.e. scenario analysis and real-time market intelligence.

7.4. Social Safety Nets that are Scaling with Shocks

Adaptive food security systems are based on social safety nets, especially in respect of vulnerable groups that are disproportionately impacted by climate shocks. In traditional safety net programs, there is a tendency to have a set budget and eligibility limits that hamper the quick response to the sudden rise in need. By using adaptive safety nets, in contrast, they are created to be automatically scaled to economic or environmental shocks (World Bank, 2025; FAO, 2022a).

These can be in the form of conditional cash transfers, food assistance programs, and public works schemes, which increase coverage when indicators like unemployment rates, food prices or severity of a disaster surpass predetermined levels (Alderman & Haque, 2007). The use of digital payment platforms and built-in databases of the beneficiaries facilitates quick delivery of aid and minimizes the administrative laggards and leakages.

Not only do they adopt scalable safety nets safeguard household consumption but also help to maintain macroeconomic stability by generating aggregate demand in times of crisis. In addition, adaptive safety nets, when integrated with information systems about climate risks, can be used as proactive tools to enhance resilience prior to the escalation of shocks into humanitarian crises (IPCC, 2022).

8. Case Studies and Supporting Evidence

8.1. South Asia: Food Shocks and Adaptive Responses

Climate sensitivity and vulnerability is high throughout South Asia, especially in climate-sensitive food systems in Pakistan, India, and Bangladesh. The region is prone to floods, cyclones and temperature fluctuations that affect food production and elevate the risk of food insecurity (FAO, 2023a; IPCC, 2022).

In Pakistan, floods occur in 2022 was one of the country's most devastating climate change events, impacting millions of people and destroying large swaths of farmlands. This led to the loss of crops, disruptions in rural livelihoods and food price increases due to the scarcity of agricultural production and supply chain disruptions. This led to increased poverty and food insecurity, with the government and international agencies increasing social protection measures, food aid, and recovery programs to help families (World Bank, 2023; UNOCHA, 2022).

In India, government institutions such as buffer stocks through the public distribution system play a significant role in food security. The Food Corporation of India (FCI) is responsible for purchasing, storing and distributing food grains to control prices and create supply during crop failures or climate shocks. Tactical grain reserves enable the government to swiftly address supply shortages and ensure food security in crises (FAO, 2022b). Adaptive approaches to disaster risk management in Bangladesh focus on community based early warning and disaster preparedness. Programmes like Cyclone Preparedness Program (CPP) combine early warning, evacuation and community mobilization to reduce the impact of disasters and increase flood and cyclone resilience. These proactive measures allow households and farmers to anticipate and prepare for disasters, reducing food security risks (UNDP, 2021; UNDRR, 2023).

In summary, these country-level experiences show that adaptation measures like expansion of social protection, strategic food reserves, and early warning systems are key policy tools to build climate resilience to food shocks in South Asia.

8.2. Adaptive Programs in Africa for Drought Response

African countries have developed adaptive programs to respond to recurrent drought and food insecurity. These programs focus on flexibility, speedy response and participation. The Productive Safety Net Program offers regular food or cash transfers to vulnerable households in times of drought, cutting down on urgent

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humanitarian assistance. The Hunger Safety Net Program in Kenya provides timely support to drought-affected pastoralists through mobile payments. Some Sahelian countries have adaptive livestock insurance that is triggered by rainfall indices, automatically triggering payments in periods of drought.

8.3. International Early Warning Systems

Early warning systems are essential to adaptive food security because they offer timely information to inform decisions in the face of climate uncertainty. The most well-known system is the Famine Early Warning Systems Network (FEWS-NET), which tracks weather, food production and markets in at-risk areas. Other key global systems include: The Integrated Food Security Phase Classification (IPC), which provides a classification of the severity of food insecurity and informs humanitarian action. NASA and other international climate monitoring agencies' satellite-based drought monitoring systems. Such tools can help governments and international agencies to predict food shortages months before they occur and prepare for them through food imports, subsidies and food stockpiles.

9. Food Security Lessons from Previous Climate-Induced Crises

Past food crises offer lessons on how to build adaptive food policy frameworks to respond to uncertainty and shocks. The famine in the Horn of Africa in 2011 underlined the impact of a slow response and poor institutional coordination. The food price crisis (2007-2008) highlighted the need for strategic food stockpiles and flexible trade policy. Recent climate-related events have highlighted the importance of integrated risk management approaches that include early warning, social protection and climate-resilient agricultural practices. While adaptive food security policies are increasingly recognized as critical instruments for dealing with climate uncertainty, there are several structural, institutional and socio-economic constraints that impede their effectiveness. These constraints are more pronounced in developing nations, such as Pakistan, where policies are shaped by climate threats, budgetary constraints and governance capacity. Overcoming these challenges is essential to ensure effective and adaptable food systems.

9.1. Data Gaps and Forecast Uncertainty

Good data and forecasting are critical for adaptive food security. But many nations lack climate, agricultural and market data systems. Key challenges include Gaps and outdated information on agriculture, especially in rural areas. Poor coverage of weather stations and lack of early warning systems. Climate projections are uncertain, particularly at a local scale and limited data sharing between agencies

Climate uncertainty makes food supply and demand forecasting difficult because of the variability in weather and pests, and global food prices. Even sophisticated early warning models (such as the Famine Early Warning Systems Network (FEWS NET) are unable to fully predict unexpected events or localized crises.

9.2. Institutional Inertia and Political Economy Barriers

Institutional inertia, or an organization’s resistance to changing procedures, is a significant barrier to adaptive food security policy. Government institutions tend to adopt conventional planning approaches that are not suited to rapid adaptation to climate variability.

Common barriers include rigid bureaucracies and decision-making processes as well as poor institutional coordination among agriculture, climate and disaster management. Short-term political incentives to prioritize short-term policy rather than long-term investments. In addition, Political opposition from vested interests. For instance, during international food crises such as the global food price crisis (2007-2008), governments in some countries postponed policy reform due to political and bureaucratic reasons.

9.3. Resource and Implementation Shortfalls

Resilient food security systems need continuous investments in infrastructure, technology and social protection. But financial resource limitations pose a significant challenge, especially in low- and middle-income countries. The key funding issues in climate adaptation and food security systems are the inadequate government funding for resilience initiatives and food security planning. Developing nations also have

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limited access to global climate finance mechanisms, which limit their ability to finance adaptation infrastructure and risk mitigation. Further, the slow release of funds in times of crisis frequently hampers timely response measures, thereby impeding effective emergency response. A key limitation is also the lack of robust monitoring and evaluation (M&E) structures, which limit transparency, accountability and evidence-based decision-making in the use of financial resources. Multilateral institutions such as the World Bank, Green Climate Fund, and fund climate adaptation initiatives. But the funding provided may be inadequate to address climate risks.

9.4. Equity in Adaptive Allocation

Adaptive policies for food security seek to allocate resources effectively. While equity issues occur when people are disproportionately affected by the lack of access to assistance. Issues of equity include disparities in access to early warning information, gender inequalities in resource allocation, exclusion of smallholder farmers and rural communities, geographical disparities in infrastructure and services. For Instance, during the climate disasters such as Pakistan's 2022 flood, marginalized groups faced delays in access to relief and recovery.

10. Future of Adaptive Food Security in a Climate Change World

In a warmer and more variable climate, and with a more complex food system, future food security measures will increasingly involve use of new technologies, digital governance and anticipatory policy systems. Emerging technologies such as artificial intelligence, remote sensing and anticipatory governance systems will likely dominate institutional responses to food security. This development is important for climate vulnerable countries such as Pakistan and other developing countries in designing an adaptive food system.

AI-Driven Adaptive Food Policy

The use of Artificial Intelligence (AI) in public policy processes is likely to have a profound impact, especially in the context of uncertain food systems. AI-driven systems can process vast amounts of data, detect trends and patterns, and provide predictive insights to support adaptive and evidence-based policy development in a changing world. Through the integration of data from climate science, agriculture production systems and market information systems, AI can improve the agility and effectiveness of food security governance.

The use of AI in food security systems may involve the creation of predictive models to forecast crop yield based on climatic, soil and remote sensing data. AI can also help to predict drought and flood events, allowing governments to take proactive measures to mitigate risks and minimize food losses from disasters. Also, AI-based systems can enable real-time food distribution planning to balance supply and demand at regional levels, reducing food shortages and food waste. AI technologies can also be used to develop early warning systems for food price spikes and market shocks, enabling governments to anticipate and mitigate price inflation and supply shocks.

Multilateral institutions like the Food and Agriculture Organization and the World Bank are encouraging the adoption of AI-powered decision support systems to support food planning, boost agriculture productivity, and improve food security. These programs highlight the importance of data-driven decision-making, digital innovation and multi-sectoral partnerships in building resilient and adaptive food systems.

Climate-Resilient Digital Governance

Digital governance is essential for mainstreaming climate adaptation policies across levels of governance. Climate-resilient governance systems leverage digital infrastructure, data and communication technologies to foster transparency, responsiveness and accountability.

The components of climate-resilient digital governance are digital databases for agriculture, climate and disaster management agencies. Mobile services to farmers and households, real-time food stock and supply chain management, online disaster monitoring systems. For instance, e-Governance projects funded by the

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United Nations Development Program have improved disaster management and food security in developing countries.

Satellite Data and Monitoring

Remote sensing and satellite-based systems are being used to monitor crop production, weather and natural disasters. This data provides timely information to inform policies and strategies and support early warning.

Major applications include evaluating crop and vegetation status, detection of droughts, floods and degradation, impact assessment on food production and supply chain, and supporting the climate risk mapping and disaster risk reduction. Organizations such as the National Aeronautics and Space Administration and the European Space Agency provide satellite data that governments can use to improve food security.

Shifting Towards Anticipatory Governance

Anticipatory governance is a shift from reactive to proactive governance. Governments react to risks and potential crisis situations, rather than the effects of a food crisis. Anticipatory governance is made up of risk simulations and scenario planning, pre-determined funding arrangements, policy flexibility to adapt, and national-local institutional connections. International monitoring networks such as the Famine Early Warning Systems Network (FEWS NET) will help anticipatory governance through early warning of food insecurity. Adaptive food security policies will be shaped by the interaction of technology, governance reform and predictive analytics. The transition towards artificial intelligence, digital governments and anticipatory governance will shape future government responses to climate-related food security.

11. Conclusion

This chapter stressed that food security systems need to adapt to growing climate change uncertainty, environmental and socio-economic variability. Existing food security policies, which are often developed in stable environments, are inadequate to deal with dynamic risks and uncertainty, such as droughts, floods, market prices and supply chain crises. The research identified the importance of adaptive decision-making approaches for managing uncertainty and dynamic environments.

Experience from climate-vulnerable areas in Pakistan, Bangladesh, and some African economies shows that adaptive food security policies, backed by early warning systems, social protection measures, and institutional coordination, can boost resilience. Examples of programs funded by international institutions like the Food and Agriculture Organization and the World Food Program demonstrate the value of incorporating climate risk management in food security programs.

In conclusion, the chapter demonstrated that adaptive governance systems that are flexible, agile, and responsive are critical to achieve food security under climate change.

Need to Move from Static to Adaptive Governance

The shift from static policy frameworks to adaptive governance is a key theme in this chapter. Static governance systems are based on rigid rules, long-term planning and crisis management. Adaptive governance focuses on learning, timely information, and anticipatory risk governance.

This transition is essential in the face of growing climate variability and global food price volatility, such as the 2007-2008 global food price crisis and 2022 Pakistan floods. These crises highlighted the impact of policy lag on food security and economic downturn.

Adaptive governance allows governments to react quickly to food security threats, including new evidence and data in policy making as well as to engage in effective inter-institutional and inter-sectoral coordination to build the resilience of vulnerable groups.

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For developing economies, where farming systems are highly vulnerable to climate change and governments have limited financial capacity, the shift towards adaptive governance is desirable and essential for future development.

Policy Implications for Global and Developing Economies

The shift to adaptive food security systems has important policy implications for both developing and developed economies. To build resilient food systems under climate change, governments need to build capacity, enhance data collection and promote participatory governance. Policy insights for improving adaptive food security systems highlight the importance of institutional capacity building, coordination and innovation for climate risk management.

First, strengthening capacity for climate information and early warning systems is crucial; countries should establish national information, monitoring and forecasting systems to better inform decision-making and speed up response in food crises. Second, enhancing policy flexibility and co-ordination is essential; nations should adopt integrated governance frameworks that encourage co-ordination among agriculture, climate, and disaster management agencies to provide timely and consistent responses to risks. Third, expanding social protection and risk management programs is crucial to protect vulnerable households; effective safety nets, insurance, and emergency support can reduce the impact of shocks and stop temporary food insecurity from turning into chronic food insecurity. Finally, promoting innovation in food security systems using new technologies, such as digital platforms, artificial intelligence and satellite monitoring, can improve planning, resource allocation and response in real time, improving the resilience and sustainability of national food.

Additionally, to mitigate food and resource disparities, governments need to better prioritize the needs of marginalized people, especially smallholder farmers and the poor. Inclusive policies can improve resilience and food security in the long run. Meanwhile, enhanced multilateral engagement is crucial to global food security. Multilateral organizations such as the World Bank, International Food Policy Research Institute, and the Intergovernmental Panel on Climate Change (IPCC) play a critical role in offering financial assistance, research and policy recommendations to promote sustainable and inclusive food systems globally.

Lastly, as the world faces a climate uncertain future and unprecedented global interconnectedness, food security policies need to shift from static to dynamic, evidence-based governance. The future of food production will be determined by the capacity of institutions and governments to forecast threats and challenges, adapt and learn, and manage risks in a changing environment and economy.

References

Alderman, H., & Haque, T. (2007). Insurance against covariate shocks: The role of index-based insurance in social protection. *World Bank Economic Review, 21*(2), 295–312. https://openknowledge.worldbank.org/server/api/core/bitstreams/3c173cac-db44-5819-ab32-47d28db7e075/content

Anderson, K., & Nelgen, S. (2012). Trade barrier volatility and agricultural price stabilization. *World Development, 40*(1), 36–48. https://doi.org/10.1016/j.worlddev.2011.05.018

Armitage, D., Marschke, M., & Plummer, R. (2008). Adaptive co-management for social–ecological complexity. *Frontiers in Ecology and the Environment, 7*(2), 95–102. https://doi.org/10.1890/070089

Barnett, B. J., Barrett, C. B., & Skees, J. R. (2008). Poverty traps and index-based risk transfer products. *World Development, 36*(10), 1766–1785. https://doi.org/10.1016/j.worlddev.2007.10.016

FAO. (2001). The state of f*ood insecurity in the world*. Food and Agriculture Organization. https://www.fao.org/agrifood-economics/publications/detail/en/c/122100/

FAO. (2010). *Climate-smart agriculture: Policies, practices and financing for food security, adaptation and mitigation*. Food and Agriculture Organization. https://www.fao.org/4/i1881e/i1881e00.htm

FAO. (2016). *Climate change and food security: Risks and responses*. Food and Agriculture Organization. https://openknowledge.fao.org/server/api/core/bitstreams/a4fd8ac5-4582-4a66-91b0-55abf642a400/content

FAO. (2022a). *The future of food and agriculture: Drivers and triggers for transformation*. Food and Agriculture Organization. https://doi.org/10.4060/cc0959en

FAO. (2022b). *The state of food insecurity in the world*. Food and Agriculture Organization. https://openknowledge.fao.org/server/api/core/bitstreams/67b1e9c7-1a7f-4dc6-a19e-f6472a4ea83a/content

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FAO. (2023a). *Asia and the Pacific regional overview of food security and nutrition*. Food and Agriculture Organization. https://doi.org/10.4060/cc8228en
FAO. (2023b). *The state of food security and nutrition in the world 2023*. Food and Agriculture Organization. https://doi.org/10.4060/cc3017en
Haasnoot, M., Kwakkel, J. H., Walker, W. E., & ter Maat, J. (2013). Dynamic adaptive policy pathways. *Global Environmental Change, 23*(2), 485–498. https://doi.org/10.1016/j.gloenvcha.2012.12.006
Hallegatte, S. (2009). Strategies to adapt to uncertain climate change. *Global Environmental Change, 19*(2), 240–247. https://doi.org/10.1016/j.gloenvcha.2008.12.003
Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Impacts, adaptation and vulnerability*. Cambridge University Press.
Martin, W., & Anderson, K. (2012). Export restrictions and price insulation during commodity price booms. *American Journal of Agricultural Economics, 94*(2), 422–427. https://doi.org/10.1093/ajae/aar105
Myers, S. S., Zanobetti, A., Kloog, I., Huybers, P., Leakey, A. D., Bloom, A. J., Carlisle, E., Dietterich, L. H., Fitzgerald, G., Hasegawa, T., Holbrook, N. M., Nelson, R. L., Ottman, M. J., Raboy, V., Sakai, H., Sartor, K. A., Schwartz, J., Seneweera, S., Tausz, M., & Usui, Y. (2014). Increasing CO2 threatens human nutrition. *Nature, 510*(7503), 139–142. https://doi.org/10.1038/nature13179
OECD. (2023). Towards resilient *food systems: Implications for supply chain disruptions and policy responses*. Organization for Economic Co-operation and Development OECD Publishing. https://www.oecd.org/content/dam/oecd/en/publications/reports/2023/09/towards-resilient-food-systems_102d2ac9/f7998e46-en.pdf
UNDP. (2021). Climate resilient and ecosystem-based costal livelihoods. United Nations Development Programme. https://www.undp.org/bangladesh/publications/climate-resilient-and-ecosystem-based-costal-livelihoods
United Nations Office for Disaster Risk Reduction. (2023). *Early warning systems and disaster risk reduction in Bangladesh*.
UNOCHA. (2022). *Pakistan floods situation report*. United Nations Office for the Coordination of Humanitarian Affairs. https://www.unocha.org/publications/report/pakistan/pakistan-2022-monsoon-floods-situation-report-no-19-12-august-2023
Webber, M. K., & Samaras, C. (2022). A review of decision making under deep uncertainty applications using green infrastructure for flood management. *Earth's Future, 10*(7), e2021EF002322. https://doi.org/10.1029/2021EF002322
World Bank. (2023). *Pakistan floods 2022: Post-disaster needs assessment*. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099910201032325572
World Bank. (2025). *Integrated markets for: Trade policy and food and nutrition security in an era of climate change. resilient food systems*. https://doi.org/10.1596/43428
World Trade Organization. (2021). *World trade report 2021: Economic resilience and trade*.
Zhao, C., Liu, B., Piao, S., Wang, X., Lobell, D. B., Huang, Y., Huang, M., Yao, Y., Bassu, S., Ciais, P., Durand, J.-L., Elliott, J., Ewert, F., Janssens, I. A., Li, T., Lin, E., Liu, Q., Martre, P., Müller, C., … Asseng, S. (2017). Temperature increase reduces global yields of major crops in four independent estimates. *Proceedings of the National Academy of Sciences, 114*(35), 9326–9331. https://doi.org/10.1073/pnas.1701762114

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CHAPTER 13

Poverty, Inequality, and Food Access

Mustafa Kan[1,*], Ayesha Noreen[2,*], Kadir Akan[3] & Kashif Hamid Boparai[2]
[1]Department of Agricultural Economics, Agriculture Faculty, Kırşehir Ahi Evran University, Kırşehir-Türkiye.
[2]Institute of Business Management Sciences, University of Agriculture, Faisalabad-Pakistan.
[3]Department of Plant Protection, Agriculture Faculty, Kırşehir Ahi Evran University, Kırşehir-Türkiye.
Corresponding authors' email: mustafa.kan@ahievran.edu.tr, ayesha_noreen@uaf.edu.pk

Abstract

Global agricultural production has expanded significantly over the past few decades, yet widespread food insecurity persists. This reality exposes a fundamental paradox in modern development. Rather than treating hunger merely as a problem of insufficient supply, this chapter approaches it as a distributional crisis shaped by multidimensional poverty and inequality. Using Amartya Sen's entitlement approach as a conceptual foundation, the discussion moves away from traditional, availability-centric models. Instead, it adopts a broader food systems perspective to illustrate how unequal access to assets, entrenched gender dynamics, spatial barriers, and weak institutional governance actively block populations from securing adequate nutrition. The analysis also examines the impact of overlapping external shocks. Climate extremes, macroeconomic instability, and geopolitical conflicts currently operate as powerful risk multipliers, frequently locking vulnerable groups into intergenerational cycles of malnutrition. Addressing this crisis requires policymakers to look beyond the simple maximization of crop yields. To achieve genuine and inclusive food security, future frameworks must focus on dismantling these underlying structural inequalities, protecting informal food economies, and fostering resilience at the local level.

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1. Introduction: Food Insecurity as a Structural Paradox

Food insecurity has emerged as a critical global challenge in the twenty-first century. As agricultural technology has significantly improved and the volume of food produced in the world has continued to rise, a high percentage of the world population continues to experience inappropriate access to adequate, safe and nutritionally adequate food. The paradox within the structure that is reflected in this situation is that, even though food is becoming more available in the world, hunger and malnutrition are still being observed in different social economic contexts (Barrett, 2010; Sen, 1981).

The previous food security policies were primarily based on food supply, in which they assumed that hunger was to be reduced by the production of more food. However, the entitlement approach to food insecurity by Amartya Sen (1981) reveals this falsehood where he demonstrated that individuals were not prone to food insecurity because the supply of food was insufficient but because people possessed poor economic means to buy food. It is this availability-to-access that has assumed the center of the development economics as the current food security is the purchasing power of income distribution and institutional structure (Ravallion, 2016).

Successful literature is also propelling this premise that poverty is among the largest determinants of food insecurity since in fact, it constrains the ability of households to obtain adequate nutrition (Spicker, 2007). It is notable that poverty as an individual phenomenon is merely a result of unequal distribution of resources and opportunities as well as institutional support.

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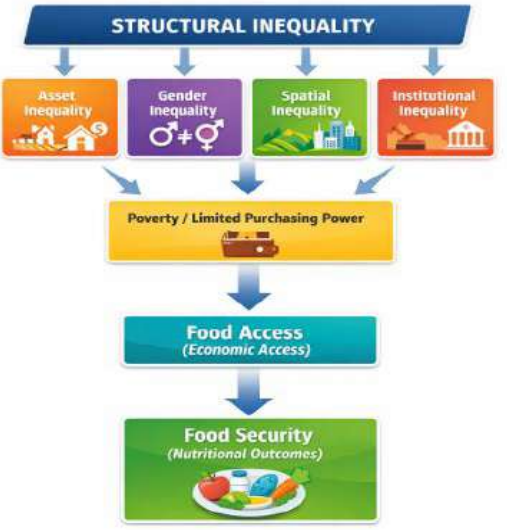

Figure 13.1: Conceptual Framework of Structural Inequality and Food Security
(Developed by the author based on Sen (1981) and Barrett (2010))

As illustrated in Figure 13.1, structural inequalities including asset, gender, spatial, and institutional disparities restrict access to resources and opportunities, which in turn contribute to poverty and limit purchasing power (De Janvry & Sadoulet, 2020; Kabeer, 1999). This framework highlights how multidimensional structural inequalities shape economic access and ultimately influence food security outcomes (Sen, 1981; Barrett, 2010). These constraints hamper access to food including the inaccessibility of sufficient and nutritious food by households. Sen (1981) notes that food insecurity is a much more of an accessibility issue, rather than an availability issue. Limited access, on its part, causes an unsuitable food security expression, i.e. malnutrition and susceptibility (Barrett, 2010).

Population is also the cause of stress on food systems, particularly in Third World countries where economic systems have less strength. The population growth is overburdening the agricultural resources (demand), population (demand), and land (demand). The effect of it is mediated through structural inequalities, however, which promotes the thesis statement that food insecurity is not necessarily a demographic phenomenon but is distributional.

The figure 13.2 outlines a causal pathway of food insecurity starting with structural causes such as poverty, population growth, and climate change. These macro-level drivers lead to agricultural stress and supply limitations, which decrease food production and disrupt supply chains (Godfray *et al*., 2010). Subsequent effects include rising food prices, reduced purchasing power, and limited access to food, ultimately resulting in food insecurity (Figure 13.2). The result of this imbalance is increased food prices, which have a skewed impact on the low-income population (Headey & Fan, 2008). Households are affected by price increases such that they have lower purchasing power to acquire proper food. Regular with the argument of Sen (1981), food insecurity is caused by unavailability and not availability.

Finally, low buying power means that there is less access to food and food insecurity ensues in the form of hunger, malnutrition, and vulnerability (Barrett, 2010). The figure emphasizes the point that food insecurity is systemic consequences of structural inequalities.

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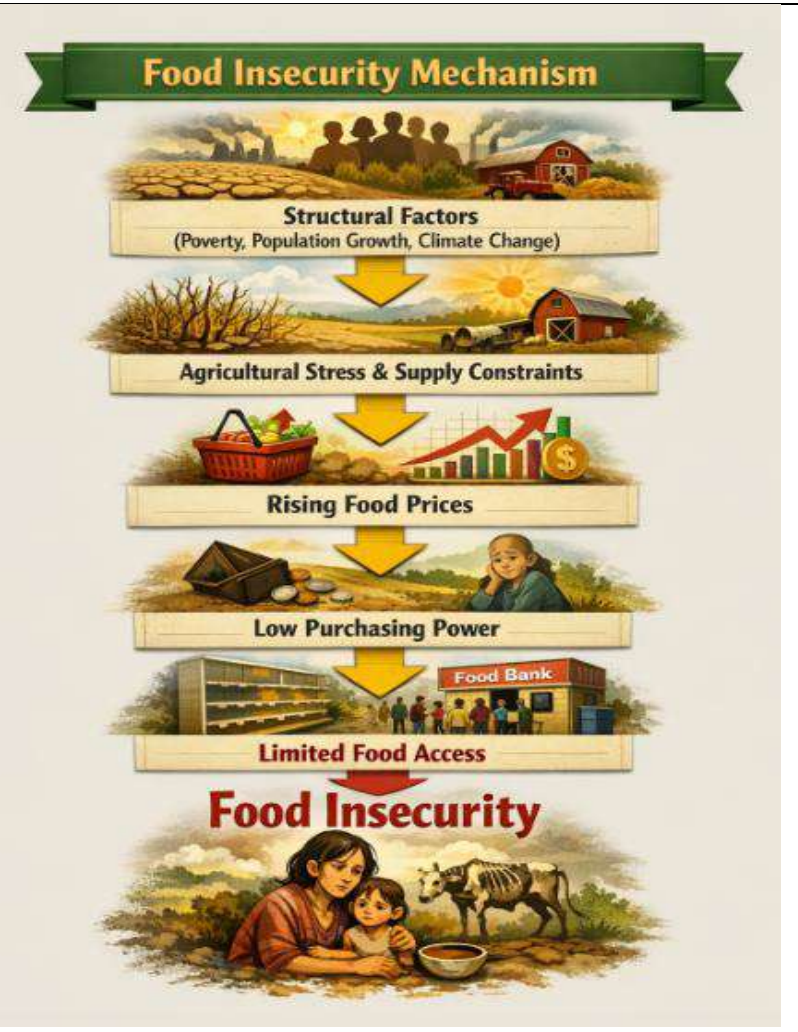

Figure 13.2: Process Chart of Food Insecurity Mechanism

Economic inequality also supports the problem of inequality in accessing food by focusing resources on certain groups sidelining others. Unequal wealth and income prevent access to food even in the cases of food surplus (Piketty, 2014). These inequalities are anchored on the historical and structural processes that define land, capital, and opportunities accessibility. Food security dynamics are further complicated by environmental factors, especially climate change. Extreme weather frequency is interfering with agricultural production and supply chains. These effects are, however, unevenly distributed, with the populations that have limited adaptive capacity being unequally affected, which strengthens the structural vulnerability.

The Social Determinants of Health model relates food security with other socio-economic factors like access to education, employment, and the standard of living (Marmot *et al*., 2012). Equally, Structural Vulnerability Theory describes how disenfranchised groups are strategically disposed to greater food insecurity against those in lower socio-economic classes because of their status in socio-economic hierarchies (Quesada *et al*., 2011).

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Table 13.1: Key Drivers of Food Insecurity

Factor	Explanation	Example
Population Growth	Rapid increase in population increases food demand	Higher demand for food resources
Poverty	Low income reduces ability to purchase food	Households unable to afford nutritious diets
Economic Inequalities	Unequal distribution of wealth limits food access	Marginalized communities at higher risk
Climate Factors	Floods, droughts and disasters affect crops	Agricultural losses due to extreme weather

Note: The factors and examples are based on evidence from international food security studies and reports (FAO, 2019; UN DESA, 2021; UN Food Systems Summit, 2021; World Bank, 2022a).

Table 13.1 describes the major causes of food insecurity and expounds on the demographic, economic, social, and environmental factors that cause a lack of access to food. The rapid population growth causes a high total demand of food, which puts pressure on food systems and food resources (United Nations Department of Economic and Social Affairs [UN DESA], 2021). Food insecurity is also a problem that is compounded by poverty since low-income families cannot afford to eat enough healthy food, and therefore they are restricted in their dietary quality and variety (Food and Agriculture Organization [FAO], 2019). Marginalized populations are disproportionately impacted by economic inequalities, such as unfair distribution of wealth and resources, which decrease their access to proper food (UN Food Systems Summit, 2021). Floods, droughts, and other extreme weather events are climate factors that directly affect the productivity of agriculture and interfere with food supply chains, making them more vulnerable to food shortages (World Bank, 2022a). Combined, these factors demonstrate the intricate interaction of structural and environmental factors, and there is the necessity to use combined policy strategies to effectively combat food insecurity.

Table 13.2: Research Focus and Objectives

Research Component	Description
Central Problem	Food insecurity persists despite increasing global food production
Research Gap	Limited studies analyze food insecurity as a structural paradox
Research Objective	Examine how poverty, population growth and inequality shape food security
Policy Relevance	Provide insights for policies addressing poverty and improving food access

Note: The table synthesizes core elements guiding this chapter's inquiry into structural determinants of food insecurity (FAO, 2019; Shostak, 2023; Lukwa *et al*., 2020).

Table 13.2 provides a summary of the main research elements that lead to the analysis of food insecurity presented in this chapter. The structural dynamics of inequality unlike in traditional food security research which mainly deals with the level of production and availability are also presupposed as the core of understanding the persistence of food insecurity in global food production, regardless of the increasing global food-production. Its main issue is that despite the growth in aggregate food production, the availability of sufficient and healthy food is still unequal among populations, which is a symptom of more profound social and economic inequalities (Shostak, 2023; Lukwa *et al*., 2020). The research gap points to the lack of research to consider food insecurity as a structural paradox, which is not absolute lack of food but unequal access to resources, opportunities, and entitlements that determine access to food (FAO, 2019). Based on this, the research question of this chapter is to examine the interaction of the three main structural variables, including poverty, demographic pressures and socio-economic inequality, in limiting the realization of food security. Lastly, policy relevance underlines the idea that the knowledge acquired through this structural lens can be used to inform the interventions that extend beyond the production centered solutions to the policies that can deal with poverty, equitable resource distribution, and inclusive access mechanisms (Lukwa *et al*., 2020).

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2. Rethinking Food Access: Conceptual and Structural Foundations

The issue of food access constitutes one of the most complex structural crises in contemporary food policy and development. Since the mid-twentieth century, global agricultural policies driven largely by Malthusian anxieties and the yield-centric ideologies of the Green Revolution have focused on maximizing total agricultural output to balance growing demographic pressures. Yet, as Amartya Sen (1981) demonstrated through his pioneering entitlement approach, mass starvation rarely stems from an absolute lack of food in the market (the Food Availability Decline hypothesis). Rather, it results from a collapse in individuals' legal, economic, and social capacities to command available food. His analysis of the Bengal famine permanently established that food insecurity is not merely a production problem; it is a profound distributional issue directly tied to income inequality, market mechanisms, and property rights. This paradigm shift, as Maxwell (1996) noted, paved the way for the concept of food security to evolve. It moved the focus from state-centric supply narratives to a more micro-level, rights-based perspective centered on household access constraints, self-determination, and social exclusion.

Despite this conceptual evolution, global food governance was shaped for decades by the four pillars established at the 1996 World Food Summit: availability, access, utilization, and stability (FAO, 1996). While pragmatic for providing measurable macro-policy targets, this traditional framework has become increasingly inadequate in explaining the deep power asymmetries inherent in modern food systems. To address these structural deficiencies, the High-Level Panel of Experts on Food Security and Nutrition (HLPE, 2020) formally proposed integrating "agency" and "sustainability" into the existing pillars. This new six-dimensional framework, detailed by Clapp *et al*. (2022), elevates food access from a passive market transaction to a socio-political foundation deeply connected to the principles of food sovereignty. Agency emphasizes the capacity of individuals and communities to determine what they eat, procure culturally appropriate food in a dignified manner, and participate equally in the governance of the food system (De Schutter, 2014). The sustainability component ensures that current access strategies do not usurp the food rights of future generations by depleting natural capital.

Such a broad expansion of food security parameters necessitates a methodological shift. We must move away from linear supply chain assumptions toward a complex "food systems" perspective. Traditional agricultural economic models rely on a neoclassical premise: that production cost reductions through technological innovations will naturally translate into cheap, accessible food for the consumer. In contrast, Ericksen's (2008) conceptualization demonstrates that the process extending from food production to final consumption is a non-linear ecosystem. It is deeply intertwined with cross-scale economic, political, and environmental dynamics, where local tipping points can trigger massive structural failures. Examining the political economy of this system, McMichael (2009) argues that the modern food regime focuses heavily on capital accumulation within global commodity chains rather than fostering local resilience. The concentration of the global market under the control of a few multinational corporations has systematically marginalized local producers, leaving poor consumers in the Global South defenseless against international price volatility. As a result, while modern food systems excel at producing high volumes of cheap calories, they have created a permanent crisis environment. Swinburn *et al*. (2019) termed this "Global Syndemic" a state where obesity, undernutrition, and climate change co-occur, share common corporate drivers, and mutually reinforce one another.

These macro-level structural failures ultimately manifest at the micro-level, shaping the daily contexts where people make dietary choices. Within this structural crisis network, the question of how individuals obtain food is best addressed through the concept of the "food environment." It acts as the crucial interface where systemic economic, physical, and social barriers intersect (Turner *et al*., 2018). The food environment encompasses the physical spaces where consumers encounter food, corporate pricing strategies, and the lived socio-economic context that dictates dietary preferences. The most decisive constraint here is economic access, which depends directly on the balance between household purchasing power and food price inflation. Drewnowski and Specter (2004) empirically established an inverse correlation between food costs and nutritional quality. They proved that energy-dense but micronutrient-poor "ultra-processed" foods (e.g., Monteiro *et al*., 2019) are significantly cheaper than fresh fruits, vegetables, and high-quality proteins. This

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pricing asymmetry is not a market accident. It is a direct result of global agricultural subsidies heavily favoring commodity crops like corn and soy over diverse, healthy foods. Households struggling with poverty are forced to adopt rational survival strategies, gravitating toward the cheapest calorie sources simply to prevent starvation. This economic necessity is the primary mechanism triggering the "double burden of malnutrition," a phenomenon frequently observed in developing countries where micronutrient deficiencies (like stunting and anemia) and diet-related obesity coexist within the same household or even the same individual (Popkin *et al*., 2020).

Economic constraints become even more complex when combined with spatial and social barriers. The concept of "food deserts," common in Global North urban poverty literature, describes geographic areas lacking walkable access to healthy food retail. However, as Battersby (2012) demonstrates, this framework is inadequate for the rapidly urbanizing Global South. Disadvantaged neighborhoods in these contexts are more accurately described as "food swamps" (Cooksey-Stowers *et al*., 2017). These are highly saturated environments where cheap, unhealthy fast food and highly processed alternatives numerically overwhelm healthy options. Inadequate transportation infrastructure further limits economic access by increasing the time and travel costs individuals must bear. Beyond spatial issues, social access is strictly shaped around gender roles, intra-household hierarchies, and entrenched cultural norms. As Agarwal (1997) demonstrated with her critique of the unitary household, food is not merely a product entering the household; it is a contested resource distributed according to internal balances. These balances reflect women's broader extra-household bargaining power. During economic downturns or agricultural shocks, women and girls often disproportionately reduce their own food consumption, sacrificing their physiological needs to protect the nutrition of other family members. Social access, therefore, remains a fundamental analytical lens for understanding how food distribution mirrors systemic societal disadvantages.

In modern urban food systems, particularly across Africa and Latin America, food access for the urban poor is not facilitated by formal supermarket chains, but through a vast, heterogeneous "informal economy" network. While traditional development models view the super marketization of the retail sector as the ultimate solution, Crush and Frayne (2011) explicitly emphasize that this formal transformation does not guarantee food access for the poor. In fact, it often leaves them with severe prices and spatial disadvantages. Street vendors, mobile markets, and small neighborhood grocers (spazas, kiosks) function as critical "survival economies." Informal retailers significantly soften existing access barriers by offering food in highly fractionalized, daily portions, providing flexible, interest-free credit based on social trust, and ensuring immediate physical proximity (Battersby & Haysom, 2019; Fuseini & Sichone, 2019).

Despite its importance, this vital main artery of the urban food system is highly vulnerable to external shocks, exposing the fragile social contract between marginalized citizens and the state. Systemic crises such as climate-induced supply disruptions, macroeconomic inflation, or pandemics rapidly paralyze informal networks. Resnick (2020), for instance, demonstrated how rigid lockdowns during the COVID-19 pandemic effectively criminalized informal food trade in African cities, abruptly cutting off the urban poor's primary mechanisms for food access. Béné (2020) further points out that recurring macro-shocks rapidly deplete the financial capital and operational resilience of informal food actors, who lack legal protection or state-backed social security. When informal tradespeople go bankrupt and withdraw from the system, the most basic food access channels for the poor are closed. Rethinking food access, therefore, requires a shift toward transformative policies. These policies must center not only on increasing aggregate supply but also on dismantling structural inequalities within the food environment, addressing gendered intra-household distribution, and robustly protecting informal survival economies against external shocks.

3. Poverty and Multidimensional Deprivation as Barriers to Food Access

Accessing food is, at its core, a multidimensional crisis driven by structural poverty and deprivation. It goes well beyond simple issues of agricultural supply or logistical capacity. For a long time, the neoclassical foundations of development economics looked at poverty mostly through the lens of low household income and the resulting lack of purchasing power. When viewed through this rather static framework, the basic mechanisms that dictate how people afford food are best explained by Engel's and Bennett's laws. We know

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that low-income families are forced to spend a disproportionately large share of their budgets on food—typically between 60% and 80%. Yet, this massive spending propensity still does not guarantee them adequate nutrition. This is where the nutrition transition predicted by Bennett's Law breaks down. Normally, as income rises, people replace starch-heavy staples with high-value animal proteins and fresh vegetables. However, for households living at the absolute poverty line, this transition has effectively stalled. Since they cannot even meet their fundamental need for baseline calories, these families find themselves trapped in a sheer "eat to live" survival phase, leaving them completely unable to diversify their diets.

It is often assumed that even a small increase in income will automatically improve a poor household's nutrition, but this idea is highly debated. Looking at household expenditure data, Subramanian and Deaton (1996) showed that the calorie-income elasticity for the poor is quite significant, ranging between 0.3 and 0.5. However, they also discovered a fascinating behavioral nuance. When people in poverty get a little extra money, they don't simply try to buy the absolute maximum amount of basic nutrients. Instead, they tend to switch to better-tasting, slightly more expensive foods. Banerjee and Duflo (2011) explore this behavioral side of poverty even further. They observe that spending decisions are not driven purely by a biological need to survive. During harsh and exhausting lives, individuals are also seeking momentary pleasure, a sense of dignity, and social status. This reality makes even more sense when viewed through the lens of Mullainathan and Shafir's (2013) "scarcity" theory. They explain how the constant, daily pressure of poverty essentially drains a person's "cognitive bandwidth." When someone is constantly stressed about paying today's bills or securing their next meal, it leaves very little mental space for long-term health or dietary planning. Consequently, they often lean toward impulsive, easily accessible, calorie-dense foods simply because the structural burden of poverty makes long-term decision-making incredibly difficult.

Because of these tight budget limits and cognitive burdens, poor families remain incredibly vulnerable not just in their day-to-day lives, but especially when macroeconomic or climate shocks hit. However, how they experience this vulnerability depends heavily on their environment, as urban and rural poverty require entirely different strategies for accessing food. Looking at urban settings, Cohen and Garrett (2010) point out that the food security of the urban poor relies almost exclusively on cash income and market prices. Unlike rural populations, residents of urban slums do not have the safety net of growing their own food or foraging. As a result, when global food inflation strikes, they absorb the most severe blows. Yet, being in a rural area is certainly no safe harbor. In their work on agriculturally dependent economies, Dercon and Krishnan (2000) shed light on the drastic, intra-annual shifts in how much food families consume. They highlight the devastating reality of the "lean season" or "hungry season." This is that brutal stretch of months when the old harvest has been depleted and the new one isn't ready yet. During this gap, volatile incomes wipe out purchasing power, plunging rural communities into cyclical periods of near famine. Things get significantly worse when sudden food price spikes are added to the mix. When budgets are stretched to the breaking point, how do families cope? D'Souza and Jolliffe (2012) offer a clear answer: people abandon expensive, nutrient-rich foods like meat, dairy, and fresh vegetables, falling back on the absolute cheapest carbohydrates just to maintain their daily calorie counts. This asymmetric price elasticity is a stark reminder of how quickly, during a crisis, income poverty translates directly into "hidden hunger" and severe micronutrient deficiency.

It has become increasingly clear across both development and public health research that measuring poverty strictly through income or expenditure is far too narrow. These unidimensional metrics simply fail to capture the real, everyday barriers families face when trying to access food. This is exactly why the Multidimensional Poverty framework, pioneered by Alkire and Foster (2011), is so critical. They treat poverty not just as a financial deficit, but as a complex web of simultaneous deprivations spanning health, education, and basic living standards like housing and fuel. From this angle, acquiring food is no longer just a simple transaction between a wallet and a market stall; it is deeply intertwined with the physical and infrastructural environment of the household. This reality brings us to the often-overlooked "utilization" dimension of food security. It is not merely about filling a stomach, but whether the body has the biophysical capacity to process and absorb those nutrients. In the medical literature, Katona and Katona-Apte (2008) describe a devastating "synergistic cycle" between undernutrition and infectious diseases. When poor children are undernourished, their immune

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systems weaken, leaving them highly vulnerable to infections. Once sick, their bodies struggle to absorb nutrients, which only deepens their malnutrition. A major trigger at the core of this vicious cycle is poor infrastructure. As Cumming and Cairncross (2016) point out, if a family lacks safe drinking water and basic sanitation (WASH), they will struggle to stay adequately nourished even if they have enough money to buy food. Keusch *et al*. (2013) explain the biological mechanism behind this tragedy through "environmental enteric dysfunction." When individuals live in areas with poor sanitation and are constantly exposed to fecal pathogens, their intestinal lining becomes severely damaged. The gut simply loses its ability to absorb essential micronutrients like iron and zinc. Ultimately, the absence of something as basic as clean water acts as a massive structural wall, physically stripping away a person's biological ability to access food.

There is another crucial, yet frequently ignored, piece of the multidimensional poverty puzzle: "energy poverty." When families lack access to modern energy services such as electricity or clean cooking fuels, achieving true food security becomes nearly impossible. As Pachauri and Spreng (2011) point out, without something as basic as a refrigerator, poor households cannot safely store fresh, micronutrient-dense foods. Instead, they are practically pushed toward relying on long-lasting processed items or lower-quality grains. But this lack of modern infrastructure triggers a secondary, more hidden crisis inside the home. Relying on traditional biomass fuels like wood or animal dung means that food preparation takes an agonizing amount of time, resulting in a profound "time poverty" for women. Johnston *et al*., (2018) captured this dynamic perfectly in their work on the agri-nutrition disconnect. They observed that the exhausting hours rural women spend just gathering firewood and fetching water aggressively eat into the time needed for breastfeeding or preparing nutritious meals. Essentially, when women are crushed under the dual burdens of agricultural labor and unpaid care work, the nutritional quality of their children's diets often declines—even if the household's overall income happens to increase. Because these burdens are deeply structural, solving child malnutrition requires looking beyond standard economic fixes. In fact, research by Alderman and Headey (2017), alongside the sweeping findings of Smith and Haddad (2015), makes a compelling case that social empowerment is the real key. Their data consistently shows that improving women's access to education and increasing their decision-making power within the household boosts child nutrition far more robustly than simple macroeconomic growth.

When all these different layers of deprivation, economic, infrastructural, temporal, and even cellular collide, they create something incredibly difficult to escape: a "poverty trap." Carter and Barrett (2006) framed this perfectly through their concept of asset-based poverty traps. They essentially argue that if a household begins life below a specific baseline of capital and health, the system is rigged against them. No matter how rational or hardworking their decisions might be, they simply cannot pull themselves up without external intervention. This harsh reality profoundly shapes how people make daily choices. In his work on agricultural behaviors, Dercon (2002) observed a strong "risk aversion" among poor farmers, driven primarily by the terrifying prospect of starvation. Imagine being a producer with no crop insurance and zero access to credit. In that precarious position, it makes total sense to stick to traditional farming methods; they might yield very little, but they guarantee at least some food regardless of the weather. Taking a gamble on innovative, high-yield seeds that could fail completely during a drought is simply a risk they cannot afford. While this "safety-first" mindset keeps families alive in the short term, it ironically locks them into chronic poverty by blocking any meaningful growth in their income or dietary diversity. Taking this a step further, Dasgupta (1997) provides a fascinating look at the physiological side of this trap through its capacity curve model. He points out a grim biological reality: if a person cannot consume their minimum required calories, their physical capacity to perform labor plummets. As they become less productive, they are forced to accept lower wages or are pushed out of the labor mark*et al*together. Ultimately, they end up confined in a permanent, self-sustaining loop of exhaustion and destitution.

What makes these intertwining poverty traps truly devastating is that they do not simply end with one person's life cycle; rather, they are physically passed down to the next generation through subtle epigenetic and metabolic channels. Public health literature is stunningly clear on this reality. As Black *et al*. (2013) have shown, when a woman experiences undernutrition and stunting during her own childhood, she faces a drastically higher risk of delivering a baby with restricted fetal growth and low birth weight. In the medical

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world, this tragic intergenerational handoff is often understood through the Barker Hypothesis, or the Developmental Origins of Health and Disease (DOHaD). Gluckman *et al*. (2008) provide a fascinating, if bleak, explanation for how this works. They note that if a child is exposed to famine or severe undernutrition in the womb and during their first 1000 days, their metabolism is essentially hardwired to survive in an environment of extreme scarcity. The real problem arises when these individuals grow up and suddenly find themselves in environments flooded with cheap, ultra-processed, calorie-dense foods a common reality for those who migrate from rural villages to urban slums. Because their bodies were genetically programmed to hoard energy, they cannot simply burn off these sudden, excess calories; instead, they store them directly as fat. This profound biological mismatch helps us understand a frustrating modern paradox: why some of the poorest populations in the developing world are currently fighting both early childhood stunting and adult obesity at the exact same time the dreaded "double burden" of malnutrition. Ultimately, what begins as an economic class issue transforms into a permanent metabolic legacy, written directly into the biology of the next generation.

Ultimately, this vicious cycle of nutritional deficiency and poverty doesn't just harm the individual; it leads to a catastrophic erosion of human capital on a global scale. When we look at the economics of human development, Nobel laureate James Heckman (2006) makes a compelling case through his famous "Heckman Curve." He clearly shows that investing in the nutrition and early cognitive development of disadvantaged children yields far greater economic returns than trying to fix the damage with compensatory programs later in life. The harsh reality is that the neurological setbacks caused by early childhood malnutrition are practically irreversible. We can see the fallout of this play out in the data. For instance, Glewwe *et al*. (2001) observed that early nutritional deprivation permanently impairs a child's academic skills. The long-term economic penalty for this is staggering. Drawing on the famous longitudinal INCAP data from Guatemala, Hoddinott and his colleagues (2008) revealed that children who had access to high-quality nutrition grew up to earn hourly wages a remarkable 46 percent higher than their undernourished peers. But what happens when we scale these individual, micro-level tragedies up to a national level? Galasso and Wagstaff (2019) ran the numbers and estimated that childhood stunting essentially acts as a massive penalty on developing economies, striking away between 5 and 7 percent of their per capita GDP every single year. When you put all this together, the final takeaway is undeniable. The barriers preventing the poor from accessing food are not simply matters of social welfare or charity; they represent a fundamental, structural catastrophe. They cripple education systems, devastate future labor forces, and ultimately destroy the long-term economic resilience of entire societies.

4. Inequality in Assets, Gender, Space, and Institutions

One of the structural causes of food insecurity in developing nations is inequality, which is One of the structural causes of food insecurity in developing nations is inequality, which is still persistent. Although world food production has grown tremendously in recent decades, food remains unevenly distributed because of the unequal distribution of assets, gender relations, spatial development, and institutional structures. These disparities do not occur in isolation, but instead, they interact in complicated manners to determine the outcome of household-level food security. These interconnections are important in understanding the ways to develop effective and inclusive policy interventions.

Food insecurity in agrarian economies is based on land and productive asset disparity. Rural livelihoods and agricultural productivity are well known to depend on access to land. Nevertheless, land distribution in most developing nations is extremely skewed because of the historical legacies of land tenure systems (colonialism) and the ineffective land reform policies (Deininger & Feder, 2009; Jayne *et al*., 2014). Small farmers who form a significant percentage of the rural poor are usually working on small pieces of land where they have minimal access to irrigation, better seedlings and financial services. Large landowners, in their turn, possess large blocks of arable land and more access to capital-intensive inputs, which allow them to occupy the position of agricultural market leaders and shape the policy-making process (HLPE, 2023).

Such unequal distribution forms a dualistic agricultural system where there is subsistence farming on one side and commercialized agriculture on the other side. Accordingly, national food production is not always

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positively related to household-level food access. Asset inequality also goes beyond land to argue livestock, machinery, storage infrastructure and financial capital. Households that do not have such assets are quite susceptible to exogenous shocks in the form of climate change, price fluctuations, or health emergencies (Barrett, 2021; FAO, 2023a).

The patterns of land distribution in South Asia, Sub Saharan Africa and Latin America have critical differences which are emphasized in Table 13.3 and which illustrate how disparities in land access determine agricultural livelihoods and food security outcomes. The high concentration of small-scale agriculture in the Global South is reflected in the large percentage of farmers in all three regions who are smallholders (below two hectares) (Lowder *et al*., 2021). Smallholders also have a small portion of crop land despite their high population, with the top decile of landholders holding a disproportionately large portion of all of the agricultural land particularly in Latin America where elite domination over land is the most apparent (Oxfam, 2016).

Table 13.3: Land Distribution Patterns in Selected Developing Region

Region	% Smallholders (< 2 ha)	% Land Controlled ny Top 10%	Implication to Food Access
South Asia	85	55-60	High rural poverty, low productivity
Sub-Saharan Africa	80	50	Limited commercialization
Latin America	60	70-80	Extreme inequality

Note: Approximate values represent regional land distribution patterns in the Global South, driven by high shares of smallholder farms (<2 ha) and concentrated land ownership among top deciles (Lowder *et al*., 2021; Anseeuw & Baldinelli, 2020).

In institutional terms, the insecurity of property rights and imperfect credit markets continue to enhance the inequality of assets. Deininger and Feder (2009) observes that the smallholders who lack formal land titles are usually left out of the formal financial frameworks hence they are unable to invest in productivity enhancing technologies. This will form a vicious circle of low productivity, low income and continuing food insecurity. Figure 13.3 effectively summarizes this trend, demonstrating how limited access to land and credit systematically constrains smallholder agricultural performance.

Figure 13.3: Asset Inequality and Food Access Pathway

Besides the disparity in assets, gender inequality is also an important factor in determining the outcomes in food security. The women are the focus of agricultural production, food preparation, and nutrition at home, but they experience systematic restrictions in terms of resource access and influence on decision-making (FAO, 2023a; Doss, 2013). Most of the developing societies have socio-cultural requirements that do not allow women to own land and other productive resources, despite their contribution to the workforce in the agricultural sectors. The effect of this is what scholars refer to as the feminization of agriculture without empowerment whereby, the women are left with the burden of increased responsibilities without the ability to control resources or income.

Table 13.4: Gender Gaps in Agriculture

Indicator	Men (%)	Women (%)
Land Ownership	70	30
Access to Credit	65	35
Extension Services	75	25

As presented in Table 13.4, gender inequality is expressed through the unequal access to resources, disproportional time allocation in the face of unpaid care work, and low involvement in the household decision process. Such inequalities directly impact the intra-household food distribution, which usually puts women and girls at a disadvantage, especially during periods of scarcity (Quisumbing *et al*., 2021). It is

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empirically proven that the accessibility of productive resources can have a significant impact on the productivity of agriculture and food security of households in the case of women.

Theoretical viewpoints that are relevant to explaining the ways in which the deeply rooted gender norms influence individual agency and behavior include Social Cognitive Theory, whereas the aspect of intersectionality is a situation whereby gender combines with the notions of class, ethnicity, and geographic location to enhance the vulnerability (Crenshaw, 1989). Such intersecting inequalities put women, especially rural and marginal ones, at a highly vulnerable risk to food insecurity.

The issue of rural-urban divide, which is the form of spatial inequality, also complicates food access dynamics. The rural regions are usually characterized by poor infrastructure, poor market connection and poor reliance on livelihoods that are climate sensitive. These aspects limit food production and the generation of income (IFAD, 2021). Urban populations, on the contrary, are more susceptible to changes in food prices and income instability because they largely depend on market-based food systems (Ravallion, 2016; World Bank, 2023).

Urbanization has also worsened food insecurity in the cities, including the low earning populations in informal settlements. The development of food deserts and food swamps indicates the conditions of the lack of access to affordable and healthy food, which will cause dietary imbalance and malnutrition (HLPE, 2023).

Figure 13.4: Rural vs. Urban Food Insecurity

According to the Spatial Inequality Framework, the inequitable development policies and According to the Spatial Inequality Framework, the inequitable development policies and investments in infrastructure cause geographical differences in economic opportunities and service provision as represented in Figure 13.4. Such inequalities strengthen the poverty and food insecurity cycles in rural and urban areas, and the importance of equalizing the strategies of regional development. These inequalities are further influenced by institutional and political aspects based on power relations and governance structures. According to the political economy approach, the problem of accessing food is not only a technical matter but also strongly determined by policymaking, institutional organization, and power distribution (Sen, 1981; Acemoglu and Robinson, 2012). Corruption, poor accountability and bureaucratic inefficiency are some of the governance issues that hamper the intervention of food security in many developing nations.

Of special concern is elite capture where the politically aligned groups enjoy unequal access to subsidies, development initiatives, and other public resources at the expense of the marginalized populations (World Bank, 2023). Likewise, inverted agricultural policies are usually in favor of the large-scale producer, which strengthens structural disparities and restricts the opportunities of the smallholder. Figure 13.5 illustrates how political and economic forces shape food inequality, highlighting the advantages of elites over marginalized groups.

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Figure 13.5: Political Economy of Food Inequality

The Entitlement Approach developed by Sen also offers a practical way of analyzing these processes and the point of the issue, in that food insecurity is not only due to lack of food, but to unequal access to it based on institutional and economic considerations (Sen, 1981). The solution to food insecurity has to do with ensuring that there are comprehensive governance reforms, transparency and inclusion of policy-making processes.

To sum up, food insecurity among the developing nations cannot be explained without referring to the inequalities that underline access to resources and opportunities. Although production of food should continue to be a priority, it is not enough by itself. The challenge of inequality in all its manifestations is vital in the assurance of equitable and sustainable food systems.

5. External Shocks, Fragility, and Global Dependencies

Current challenges in accessing food cannot be attributed solely to flawed national policies or local production shortfalls. Rather, they highlight the structural fragility of a globalized system now operating in a state of "polycrisis." Lawrence *et al*. (2024) use this framework to describe a modern environment where climate shifts, geopolitical conflicts, economic instability, and supply chain breakdowns are no longer isolated events. Instead, they interact and magnify each other's effects. For decades following World War II, the global food network was designed around free trade, comparative advantage, and just-in-time delivery. This setup works exceptionally well for maximizing distribution efficiency during stable times. Yet, when multiple crises emerge, its complete lack of resilience becomes obvious. In such a tightly interconnected system, a sudden weather extreme, a localized political dispute, or a new trade embargo in one region rarely stays local. These shocks travel rapidly through global dependency networks, frequently triggering severe food access emergencies in developing nations.

At the foundation of these interconnected vulnerabilities is climate change, perhaps the most permanent external shock to the global food system. Rather than being a distant projection, the climate crisis already acts as an active risk multiplier that directly degrades agricultural output. The reality of this climate-conflict spiral is clearly documented in the 2024 "Hunger Hotspots" report by the FAO and WFP, particularly in their assessment of Africa. The authors point out that the Horn of Africa spanning Ethiopia, Somalia, and Kenya recently endured its most severe drought in four decades following five consecutive failed rainy seasons. Meanwhile, in the Sahel region (Mali, Burkina Faso, Chad, and Niger), the combination of extreme weather and ongoing violence from armed groups has pushed millions toward famine. Beyond droughts, the climate crisis also drives devastating rainfall extremes, as seen in Pakistan in 2022. The World Bank's Post-Disaster Needs Assessment report in 2022 detailed how unprecedented monsoon flooding submerged over four million acres of farmland. The disaster wiped out vital cotton, rice, and wheat harvests and killed more than 800,000 livestock, effectively paralyzing the country's domestic food supply (World Bank, 2022b).

While climate change presents a severe environmental threat, human actions have driven the most acute disruptions to the global food system in recent years. Today, we are increasingly observing geopolitical conflicts where food access is deliberately used as a weapon. As Alex de Waal (2018) points out in his

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research on mass starvation, contemporary famines rarely stem from natural disasters alone. This perspective aligns with Stephen Devereux's (2007) concept of "new famines," which argues that modern starvation is fundamentally a political construct. It typically occurs when governments or armed factions intentionally destroy agricultural infrastructure, cut off supply chains, and block humanitarian aid to subdue certain populations. The fragility of this system became particularly evident following the outbreak of the Russia-Ukraine conflict in 2022. As Ben Hassen and El Bilali (2022) note, the disruption to wheat and fertilizer supplies from these key exporting nations caused market shocks that the world is still struggling to absorb.

More recently, escalating conflicts in the Middle East have further exposed the global food network's vulnerability to geopolitical instability. Data from the Integrated Food Security Phase Classification (IPC, 2024) indicates that military operations in the Gaza Strip have decimated local food production, including farms, bakeries, and water systems. Combined with strict commercial blockades, this has pushed the region's population into catastrophic levels of food insecurity. The economic fallout has also spilled over into neighboring areas. In Lebanon, which was already facing a severe macroeconomic crisis, World Bank (2024) figures showed that annual food inflation surpassed 103 percent in early 2024, ranking among the highest globally. Furthermore, as asymmetric tensions spread to the Red Sea, major shipping lines have been forced to reroute vessels around the Cape of Good Hope. This shift has significantly increased freight and fuel costs, demonstrating how quickly a localized conflict can inflate food prices worldwide.

Driven by this growing sense of instability, major economies have increasingly turned to protectionist food policies. Martin and Anderson (2011) describe this trend as relying on "beggar-thy-neighbor" tactics, where governments implement export restrictions primarily to shield their domestic markets from inflation. A clear example occurred in mid-2023 when India halted the export of non-basmati white rice. As Glauber and Mamun (2023) note, while this decision aimed to secure local supply, it severely disrupted Global South, driving international rice prices to a 15-year peak. Similarly, China's evolving approach to food security has fundamentally altered global market dynamics. A recent USDA (2024) report highlights that China's new Food Security Law, enacted in late 2023, legally mandates strict self-sufficiency in essential grains. Reflecting this priority, the country has aggressively expanded its strategic reserves. Fan *et al*. (2023) point out that China now holds over half of the global public stocks for corn, rice, and wheat. When such substantial volumes are removed from international circulation, the amount of food available for regular trade contracts sharply. Consequently, this dynamic keeps global prices elevated, placing a disproportionate burden on lower-income, food-importing nations.

While major agricultural players in Asia focus on market protection, developed nations that historically shape global food standards are facing their own policy dilemmas. In the European Union, for example, the Common Agricultural Policy (CAP) had increasingly prioritized sustainability. Through the Green Deal's "Farm to Fork" strategy, the EU established ambitious goals to reduce chemical pesticides and expand organic farming. However, as highlighted by the OECD (2023), the supply disruptions following the outbreak of the Ukraine war prompted a rapid shift back toward food "securitization." Faced with immediate production concerns and widespread farmer protests across member states, European policymakers found themselves caught between long-term environmental commitments and immediate food security needs. As a result, the momentum for sustainable agricultural reform has noticeably slowed, presenting a significant setback for the ecological transition of the global food network.

While trade barriers and policy inconsistencies frequently dominate discussions on food crises, macroeconomic instability introduces a much deeper structural constraint. Türkiye offers a striking example of this dynamic. Despite possessing substantial agricultural capacity, the country grapples with chronic food inflation that stems more from financial vulnerabilities than actual supply shortages. Recent empirical evidence confirms that this inflationary momentum is heavily driven by the exchange rate pass-through effect (Sarı, 2024). As the local currency depreciates, the cost burden of import-dependent inputs particularly energy, commercial seeds, and fertilizers, escalates rapidly. This mechanism is structurally verified by Sarı (2025), whose advanced time-series analysis reveals a strong, long-term cointegration between agricultural input prices, exchange rate volatility, and food inflation. Interestingly, the research also points to the rising cost of financing as a critical cost-push factor. When commercial loan interest rates increase, farmers face

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tighter credit conditions that inevitably restrict their production capacity, creating secondary supply shocks and pushing retail prices even higher (Sarı, 2025). Ultimately, these dynamics illustrate a broader reality: as long as agricultural output relies on imported inputs and external credit, domestic food security will remain highly sensitive to fluctuations in global currency markets and local monetary policies.

Compounding these macroeconomic challenges is a structural deadlock within global trade governance. The World Trade Organization (WTO), traditionally the primary regulatory body for international trade, currently struggles to manage the fallout from these overlapping crises. As Glauber and Laborde (2023) observe, the WTO has been largely ineffective in addressing unilateral trade measures, such as the expansive public stockholding programs and recurrent export bans implemented by major economies. Consequently, the multilateral system is failing in its foundational role to stabilize global food security. When this institutional gridlock coincides with external shocks, the aggregate impact is clearly reflected in the FAO Food Price Index (FFPI). Historical data reveals a consistent pattern of escalating price volatility during systemic disruptions. The index recorded significant spikes during the 2007-2008 biofuel and trade policy crisis, as well as the 2010-2011 period, which was marked by severe weather anomalies and regional unrest. This upward trend culminated recently when the FFPI surged to an unprecedented nominal peak of 159.7 points in March 2022, immediately following the outbreak of the war in Ukraine (FAO, 2023b).

This pattern of persistent price volatility encountered another stress test during the localized conflict between Israel and Iran in mid-2025, which kept the FFPI elevated around the 130-point mark throughout the summer. However, the expansion of these hostilities in early 2026, involving U.S. and Israeli forces alongside Iranian retaliation, has introduced more profound systemic risks. In a recent assessment for IFPRI, Glauber (2026) details the macroeconomic transmission channels through which this conflict impacts global agricultural markets. The central vulnerability is the severe disruption of maritime traffic through the Strait of Hormuz. As shipping operations halt, the resulting surge in energy futures systematically increases the costs associated with agricultural production, machinery, and transportation. Furthermore, while Iran itself exports minimal quantities of nitrogen fertilizers, the broader Persian Gulf region is responsible for up to 30 percent of global fertilizer exports, including essential inputs like urea and ammonia. Prolonged bottlenecks in this critical maritime corridor drastically restrict global fertilizer availability. Glauber notes that these compounding input-cost shocks squeeze operating margins for farmers worldwide, likely leading to reduced fertilizer application and lower crop yields. For import-dependent developing nations, this scenario threatens to exacerbate existing food access crises and drive global food prices toward new peaks.

Table 13.5. FAO Food Price Index (FFPI) Peaks During Global Crisis Periods

Crisis Period	Core Dynamics and External Shocks	FAO Food Price Index Peak*
2007-2008 Crisis	Biofuel policies, low stocks, speculation, and export bans	132.4 (June 2008)
2010-2011 Crisis	Severe drought in Russia, geopolitical impacts of the Arab Spring, oil price increase	137.6 (February 2011)
2022-2024 Crisis	The War in Ukraine, Israel-Middle East tensions, logistical bottlenecks, and climate shocks	159.7 (March 2022)
2025 Crisis	The domino effect of the June 2025 12-Day War between Israel and Iran on the escalation of food prices.	128.1 (June 2025) 129.8 (July 2025) 130.0 (August 2025)
2026 Crisis	Israel, Iran and USA war	Still not clear and there are some estimations.

Note: Values represent nominal peak points calculated according to the FAO's 2014-2016=100 base year methodology (FAO, 2023b).

As illustrated in Table 13.5, the magnitude of price shocks in the modern era continues to intensify. The impact of these elevated costs is further compounded by the unsustainable debt burdens currently carried by developing nations. An analysis by the United Nations Conference on Trade and Development (UNCTAD, 2023) highlights that a strong US dollar, coupled with rising global interest rates, has forced lower-income countries to allocate substantial portions of their national budgets to external debt servicing. Faced with a rapidly shrinking fiscal space, these heavily indebted states are often compelled to reduce the very social safety nets required to protect their populations from food inflation. Ultimately, the convergence of these

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overlapping shocks, geopolitical conflicts in the Middle East, market protectionism in Asia, climate extremes in Africa, and the regulatory stagnation of the WTO, demonstrates that food access can no longer be approached merely as a technical issue of agricultural production. Instead, it must be addressed as a fundamental challenge of global political economy and human rights.

6. Toward Transformative and Equitable Food Access Policies

The persistence of food insecurity amidst record levels of global food production remains a central paradox in contemporary development discourse. While technological advancements and agricultural productivity have significantly expanded the global food supply, achieving widespread access to this abundance has proven difficult. This disconnect reflects deep-rooted inequalities within economic and social frameworks, illustrating that food security is less about physical availability and more heavily dependent on equitable distribution and purchasing power (Sen, 1981; Barrett, 2021). Consequently, addressing modern food crises requires a decisive shift away from purely production-centric strategies toward transformative policies that tackle these underlying structural barriers.

A cornerstone of this necessary transformation is the integration of poverty alleviation with comprehensive food system reforms. Endemic poverty continues to be the primary constraint on food access, particularly in developing economies where rural livelihoods depend heavily on agriculture. However, the relationship between agricultural growth and food security is neither linear nor automatic. Empirical literature emphasizes that simply increasing agricultural output does not inherently translate to improved nutritional outcomes unless it is paired with equitable income distribution and inclusive market access (Fan & Brzeska, 2016). This reality underscores the urgent need to design food systems that prioritize inclusivity and nutritional responsiveness alongside gross productivity.

While vital, agricultural and income-focused initiatives must be complemented by robust social protection mechanisms to secure food access for the most vulnerable populations. Relief frameworks such as cash transfers, food subsidies, and public employment programs have emerged as standard policy responses to stabilize domestic consumption during acute crises (Alderman *et al*., 2018). Although these interventions effectively mitigate short-term distress, their long-term viability is frequently undermined by targeting inefficiencies, fiscal constraints, and failure to drive structural change. Flawed targeting mechanisms, for instance, often generate exclusion errors and administrative inefficiencies that weaken the overall impact of social safety nets (Devereux *et al*., 2015). Relying solely on these safety nets without addressing systemic inequalities tends to foster dependency rather than genuine resilience, highlighting the critical need to embed social protection within broader developmental strategies aimed at economic inclusion.

The trajectory of food security policy is largely shaped by the ongoing tension between rights-based and market-based paradigms. Rights-based frameworks conceptualize food access as a fundamental human right, placing the onus on the state to ensure equitable distribution and social justice (De Schutter, 2014). This perspective prioritizes accountability and the legal protection of marginalized demographics. In contrast, market-based approaches emphasize efficiency, technological scale, and global integration as the primary drivers of food security. While open markets can efficiently increase aggregate food availability and lower unit prices, they often fail to ensure equitable access in highly unequal societies, leaving households with limited purchasing power exceptionally vulnerable (Barrett, 2021). Consequently, contemporary scholarship increasingly advocates for a hybrid strategy: leveraging market efficiencies while actively enforcing equity through rigorous regulatory frameworks and social support networks.

Structural reforms in land distribution and governance serve as essential pillars for achieving this equitable food access. Inequality in land ownership remains a chronic constraint on agricultural productivity and rural development, particularly in regions marked by historical disparities (Deininger, 2003). To invest in agriculture and sustainably improve their livelihoods, smallholder farmers require secure land rights alongside equitable access to productive resources. Simultaneously, gender-responsive governance has emerged as a critical component of inclusive food systems. Although women play a central role in food production, they frequently face significant barriers regarding land ownership, credit access, and decision-making power (Doss, 2013; FAO, 2011).

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The restructuring of rural economies further highlights the dynamic nature of these demographic challenges. Agricultural systems and labor markets are undergoing profound transformations driven by mechanization, commercialization, and rural-urban migration. As men increasingly migrate to urban centers for employment, women are assuming primary roles as agricultural producers and household heads. This phenomenon, widely recognized as the "feminization of agriculture," presents both opportunities and challenges (Slavchevska *et al*., 2016). While it can enhance women's economic participation, it simultaneously exacerbates their labor burdens and vulnerability to resource constraints. Empirical evidence indicates that with appropriate institutional support, improving women's access to resources and enhancing their agency yields substantial improvements in household food security and nutrition (Quisumbing *et al*., 2014).

Beyond socio-economic constraints, climate change introduces a severe physical threat to food security, particularly in developing nations where rain-fed agricultural systems remain highly vulnerable to environmental shocks. Rising mean temperatures, erratic precipitation patterns, and the increasing frequency of extreme weather events pose existential risks to both crop yields and supply chain logistics (Wheeler & von Braun, 2013). In response, policy frameworks have progressively prioritized climate-resilient agricultural practices, including the adoption of drought-tolerant cultivars, advanced water management systems, and sustainable land-use planning. Parallel to these technical adaptations, localized paradigms such as food sovereignty advocate for the empowerment of domestic food systems to reduce structural dependency on volatile global markets (Altieri & Nicholls, 2017). By emphasizing community governance and ecological boundaries, these approaches offer a viable alternative for building resilient food architectures.

The persistence of food insecurity in an era of unprecedented agricultural output fundamentally challenges the logic of traditional, supply-centric development models. The modern food crisis is not simply a symptom of local production deficits; rather, it is a byproduct of overlapping structural inequalities, skewed asset distribution, entrenched gender disparities, and spatial marginalization. The recent escalation of the global "polycrisis" characterized by severe macroeconomic volatility, mounting debt burdens in developing economies, and the growing gridlock within multilateral trade institutions demonstrates that isolated agricultural interventions are no longer adequate.

Securing meaningful and lasting food access requires adopting transformative political economy frameworks. Market efficiencies and social safety nets, while necessary, must be anchored by rigorous structural reforms. This necessitates a commitment to equitable land governance, the empowerment of women in rural economies, and the strategic shielding of domestic food systems from external financial shocks. Resolving the paradox of modern hunger demands a fundamental redefinition of food security: decoupling it from the sheer maximization of crop yields and repositioning it as an urgent mandate for economic inclusion, human rights, and global social justice.

References

Acemoglu, D., & Robinson, J. A. (2012). *Why nations fail: The origins of power, prosperity, and poverty*. Crown Publishing. https://www.researchgate.net/publication/254939196_Why_Nations_Fail_The_Origins_of_Power_Prosperity_and_Poverty_review

Agarwal, B. (1997). Bargaining and gender relations: Within and beyond the household. *Feminist Economics, 3*(1), 1-51. https://www.binaagarwal.com/downloads/apapers/bagaining_and_gender_relations.pdf

Alderman, H., & Headey, D. (2017). How important is parental education for child nutrition? *World Development, 94*, 448-464. https://doi.org/10.1016/j.worlddev.2017.02.007

Alderman, H., Gentilini, U., & Yemtson, R. (2018). The evolution of food as social assistance: An overview. In H. Alderman, U. Gentilini, & R. Yemtson (Eds.), The 1.5 billion people question: Food voucher or cash transfer? The World Bank. https://doi.org/10.1596/978-1-4648-1087-9

Alkire, S., & Foster, J. (2011). Counting and multidimensional poverty measurement. *Journal of Public Economics, 95*(7-8), 476-487. https://doi.org/10.1016/j.jpubeco.2010.11.006

Altieri, M. A., & Nicholls, C. I. (2017). Agroecology and food sovereignty. *Agriculture, Ecosystems & Environment, 240*, 1–13. https://doi.org/10.1016/j.agee.2017.07.014

© 2026 The Authors. Published under CC BY 4.0. | https://doi.org/10.66529/book.9786277945039.2026.ch13

Anseeuw, W., & Baldinelli, G. M. (2020). *Uneven ground: Land inequality at the heart of unequal societies*. International Land Coalition. https://www.landcoalition.org/en/uneven-ground/?utm

Banerjee, A. V., & Duflo, E. (2011). *Poor economics: A radical rethinking of the way to fight global poverty*. PublicAffairs. https://paxmongolica.org/wp-content/uploads/2019/11/poor-economics-a-radical-rethinking-of-the-way-to-fight-global-poverty-by-abhijit-v-banerjee-and-esther-duflo-pdf.pdf

Barrett, C. B. (2010). Measuring food insecurity. *Science, 327*(5967), 825–828. https://doi.org/10.1126/science.1182768

Barrett, C. B. (2021). Overcoming global food security challenges through science and solidarity. *American Journal of Agricultural Economics*, *103*(2), 422-447. https://doi.org/10.1111/ajae.12160

Battersby, J. (2012). Beyond the food desert: Finding ways to speak about urban food security in South Africa. *Geografiska Annaler: Series B, Human Geography, 94*(2), 141-159. https://doi.org/10.1111/j.1468-0467.2012.00401.x

Battersby, J., & Haysom, G. (2019). Linking urban food security, urban food systems, poverty, and urbanisation. In J. Battersby & V. Watson (Eds.), *Urban food systems governance and poverty in African cities* (pp. 56-77). Routledge. https://doi.org/10.4324/9781315191195-4

Ben Hassen, T., & El Bilali, H. (2022). Impacts of the Russia-Ukraine war on global food security: Towards more sustainable and resilient food systems? *Foods, 11*(15), 2301. https://doi.org/10.3390/foods11152301

Béné, C. (2020). Resilience of local food systems and links to food security–A review of some important concepts in the context of COVID-19 and other shocks. *Food Security, 12*(4), 805-822. https://doi.org/10.1007/s12571-020-01076-1

Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., de Onis, M., ... & Uauy, R. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet, 382*(9890), 427-451. https://doi.org/10.1016/S0140-6736(13)60937-X

Carter, M. R., & Barrett, C. B. (2006). The economics of poverty traps and persistent poverty: An asset-based approach. *The Journal of Development Studies, 42*(2), 178-199. https://doi.org/10.1080/00220380500405261

Clapp, J., Moseley, W. G., Burlingame, B., & Termine, P. (2022). Viewpoint: the case for a six-dimensional food security framework. *Food Policy, 106*, 102164. https://doi.org/10.1016/j.foodpol.2021.102164

Cohen, M. J., & Garrett, J. L. (2010). The food price crisis and urban food (in)security. *Environment and Urbanization, 22*(2), 467-482. https://doi.org/10.1177/0956247810380375

Cooksey-Stowers, K., Schwartz, M. B., & Brownell, K. D. (2017). Food swamps predict obesity rates better than food deserts in the United States. *International Journal of Environmental Research and Public Health*, 14(11), 1366. https://doi.org/10.3390/ijerph14111366

Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. University of Chicago Legal Forum, 1989(1), 139-168. https://chicagounbound.uchicago.edu/uclf/vol1989/iss1/8

Crush, J., & Frayne, B. (2011). Supermarket expansion and the informal food economy in Southern African cities: Implications for urban food security. *Journal of Southern African Studies, 37*(4), 781-807. https://doi.org/10.1080/03057070.2011.617532

Cumming, O., & Cairncross, S. (2016). Can water, sanitation and hygiene help eliminate stunting? Current evidence and policy implications. *Maternal & Child Nutrition, 12*(S1), 91-105. https://doi.org/10.1111/mcn.12258

Dasgupta, P. (1997). Nutritional status, the capacity for work, and poverty traps. *Journal of Econometrics, 77*(1), 5-37. https://doi.org/10.1016/S0304-4076(96)01804-0

De Janvry, A., & Sadoulet, E. (2020). Using agriculture for development. *World Development, 133*, 105003. https://doi.org/10.1016/j.worlddev.2020.105003

De Schutter, O. (2014). *The right to food. Report of the Special Rapporteur on the right to food*. United Nations General Assembly. https://digitallibrary.un.org/record/766914?v=pdf

de Waal, A. (2018). Mass starvation: The history and future of famine. Cambridge, UK: Polity Press.

Deininger, K. (2003). *Land policies for growth and poverty reduction.* World Bank Policy Research Report. Retrieved from http://hdl.handle.net/10986/15125

Deininger, K., & Feder, G. (2009). Land registration, governance, and development: Evidence and implications for policy. *World Bank Research Observer, 24*(2), 233–266. https://doi.org/10.1093/wbro/lkp007

Dercon, S. (2002). Income risk, coping strategies, and safety nets. *The World Bank Research Observer, 17*(2), 141-166. https://doi.org/10.1093/wbro/17.2.141

Dercon, S., & Krishnan, P. (2000). Vulnerability, seasonality and poverty in Ethiopia. *The Journal of Development Studies, 36*(6), 25-53. https://doi.org/10.1080/00220380008422653

Devereux, S. (Ed.). (2007). The new famines: Why famines persist in an era of globalization. New York, NY: Routledge.

Devereux, S., Roelen, K., & Ulrichs, M. (2015). *Where next for social protection?* (IDS Evidence Report No. 124). Institute of Development Studies. https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/5945

Doss, C. R. (2013). Intrahousehold bargaining and resource allocation in developing countries. *World Bank Research Observer, 28*(1), 52–78. https://academic.oup.com/wbro/article/28/1/52/1684725

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Drewnowski, A., & Specter, S. E. (2004). Poverty and obesity: The role of energy density and energy costs. *The American Journal of Clinical Nutrition, 79*(1), 6-16. https://doi.org/10.1093/ajcn/79.1.6

D'Souza, A., & Jolliffe, D. (2012). Rising food prices and coping strategies: Household-level evidence from Afghanistan. *The Journal of Development Studies, 48*(2), 282-299. https://doi.org/10.1080/00220388.2011.635422

Ericksen, P. J. (2008). Conceptualizing food systems for global environmental change research. *Global Environmental Change, 18*(1), 234-245. https://doi.org/10.1016/j.gloenvcha.2007.09.002

Fan, S., & Brzeska, J. (2016). Sustainable food security and nutrition: Demystifying conventional beliefs. *Global Food Security, 11*, 11–16. https://doi.org/10.1016/j.gfs.2016.03.005

Fan, S., Zhu, Y., & Fang, X. (2023). Big food vision and food security in China. *Agricultural & Rural Studies*, 1(1), 0001. https://doi.org/10.59978/ar01010001

FAO. (1996). *Rome Declaration on World Food Security and World Food Summit Plan of Action*. Food and Agriculture Organization of the United Nations. https://www.fao.org/4/w3613e/w3613e00.htm

FAO. (2011). *The state of food and agriculture 2010–11: women in agriculture – closing the gender gap for development.* Food and Agriculture Organization of the United Nations. https://www.fao.org/4/i2050e/i2050e00.htm

FAO. (2019). *The state of food security and nutrition in the world 2019*. FAO. https://www.fao.org/state-of-food-security-nutrition

FAO. (2023a). *The status of women in agrifood systems*. FAO. https://doi.org/10.4060/cc5343en

FAO. (2023b). *Food outlook: Biannual report on global food markets*. Food and Agriculture Organization of the United Nations. https://www.fao.org/family-farming/detail/en/c/1643117/

FAO & WFP. (2024). *Hunger hotspots: FAO-WFP early warnings on acute food insecurity: November 2024 to May 2025 outlook*. Food and Agriculture Organization of the United Nations. https://www.fightfoodcrises.net/sites/default/files/resource/file/HH_Nov24-May25_FINAL.pdf

Fuseini, I., & Sichone, O. (2019). Food poverty in Kitwe, Zambia. In J. Battersby & V. Watson (Eds.), *Urban food systems governance and poverty in African cities* (pp. 236-248). Routledge https://doi.org/10.4324/9781315191195-18

Galasso, V., & Wagstaff, A. (2019). The aggregate income losses from childhood stunting and the returns to a nutrition intervention aimed at reducing stunting. *Economics & Human Biology, 34*, 225-238. https://doi.org/10.1016/j.ehb.2019.01.010

Glauber, J. W., & Mamun, A. (2023). India's new ban on rice exports: Potential threats to global supply, prices, and food security. IFPRI Blog: Issue Post. Washington, DC: International Food Policy Research Institute. https://www.ifpri.org/blog/indias-new-ban-rice-exports-potential-threats-global-supply-prices-and-food-security/

Glauber, J., & Laborde, D. (2023). Trade and trade policies during crises. In 2023 Global Food Policy Report: Rethinking Food Crisis Responses (pp. 24-33). Washington, DC: International Food Policy Research Institute (IFPRI). https://doi.org/10.2499/9780896294417_2

Glauber, J. (2026). *The Iran war: Potential food security impacts*. International Food Policy Research Institute (IFPRI) Blog. https://www.ifpri.org/blog/the-iran-war-potential-food-security-impacts/

Glewwe, P., Jacoby, H. G., & King, E. M. (2001). Early childhood nutrition and academic achievement: A longitudinal analysis. *Journal of Public Economics, 81*(3), 345-368. https://doi.org/10.1016/S0047-2727(00)00118-3

Gluckman, P. D., Hanson, M. A., Cooper, C., & Thornburg, K. L. (2008). Effect of in utero and early-life conditions on adult health and disease. *New England Journal of Medicine, 359*(1), 61-73. https://doi.org/10.1056/NEJMra0708473

Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., & Toulmin, C. (2010). Food security: The challenge of feeding 9 billion people. *Science, 327*(5967), 812–818. https://doi.org/10.1126/science.1185383

Headey, D., & Fan, S. (2008). Anatomy of a food crisis. *Agricultural Economics, 39*(s1), 375–391. https://doi.org/10.1111/j.1574-0862.2008.00345.x

Heckman, J. J. (2006). Skill formation and the economics of investing in disadvantaged children. *Science, 312*(5782), 1900-1902. https://doi.org/10.1126/science.1128898

HLPE (High Level Panel of Experts). (2020). *Food security and nutrition: Building a global narrative towards 2030*. A report by the High-Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. https://openknowledge.fao.org/server/api/core/bitstreams/8357b6eb-8010-4254-814a-1493faaf4a93/content

HLPE (High Level Panel of Experts). (2023). *Reducing inequalities for food security and nutrition*. FAO. https://www.fao.org/cfs/cfs-hlpe/publications/hlpe-18

Hoddinott, J., Maluccio, J. A., Behrman, J. R., Flores, R., & Martorell, R. (2008). Effect of a nutrition intervention during early childhood on economic productivity in Guatemalan adults. *The Lancet, 371*(9610), 411-416. https://doi.org/10.1016/S0140-6736(08)60205-6

International Fund for Agricultural Development [IFAD]. (2021). *Rural development report 2021*. IFAD. https://ageconsearch.umn.edu/record/313753/files/IFAD%20Rural%20Development%20Report%202021.pdf

© 2026 The Authors. Published under CC BY 4.0. | https://doi.org/10.66529/book.9786277945039.2026.ch13

IPC. (2024). *Gaza Strip: Acute Food Insecurity Situation for 15 February - 15 March 2024 and Projection for 16 March - 15 July 2024*. Integrated Food Security Phase Classification. https://www.ipcinfo.org/ipc-country-analysis/details-map/en/c/1156872/

Jayne, T. S., Chamberlin, J., & Headey, D. D. (2014). Land pressures, the evolution of farming systems, and development strategies in Africa: A synthesis. *Food Policy, 48*, 1–17. https://doi.org/10.1016/j.foodpol.2014.05.014

Johnston, D., Stevano, S., Malapit, H. J., Hull, E., & Kadiyala, S. (2018). Review: Time use as an explanation for the agri-nutrition disconnect: Evidence from rural areas in low and middle-income countries. *Food Policy, 76*, 8-18. https://doi.org/10.1016/j.foodpol.2017.12.011

Kabeer, N. (1999). Resources, agency, achievements. *Development and Change, 30*(3), 435–464. https://doi.org/10.1111/1467-7660.00125

Katona, P., & Katona-Apte, J. (2008). The interaction between nutrition and infection. *Clinical Infectious Diseases, 46*(10), 1582-1588. https://doi.org/10.1086/587658

Keusch, G. T., Rosenberg, I. H., Denno, D. M., Duggan, C., Guerrant, R. L., Lavery, J. V., ... & Bhutta, Z. A. (2013). Implications of acquired environmental enteric dysfunction for growth and stunting in infants and children living in low-and middle-income countries. *Food and Nutrition Bulletin, 34*(3), 357-364. https://doi.org/10.1177/156482651303400308

Lawrence, M., Homer-Dixon, T., Janzwood, S., Rockström, J., Renn, O., & Donges, J. F. (2024). Global polycrisis: The causal mechanisms of crisis entanglement. *Global Sustainability, 7*, e6. https://doi.org/10.1017/sus.2024.1

Lowder, S. K., Sánchez, M. V., & Bertini, R. (2021). Which farms feed the world and has farmland become more concentrated? *World Development, 142*, 105455. https://doi.org/10.1016/j.worlddev.2021.105455

Lukwa, A. T., Siya, A., Zablon, K. N., Azam, J. M., & Alaba, O. A. (2020). Socioeconomic inequalities in food insecurity and malnutrition among under-five children: Within and between-group inequalities in Zimbabwe. *BMC Public Health, 20*, 1199. https://doi.org/10.1186/s12889-020-09295-z

Marmot, M., Allen, J., Bell, R., Bloomer, E., & Goldblatt, P. (2012). Social determinants of health inequalities. *The Lancet, 380*(9846), 1011–1029. https://psycnet.apa.org/record/2012-25699-033

Martin, W., & Anderson, K. (2011). Export restrictions and price insulation during commodity price booms. *American Journal of Agricultural Economics, 94*(2), 422-427. https://doi.org/10.1093/ajae/aar105

Maxwell, S. (1996). Food security: A post-modern perspective. *Food Policy, 21*(2), 155-170. https://doi.org/10.1016/0306-9192(95)00074-7

McMichael, P. (2009). A food regime genealogy. *The Journal of Peasant Studies, 36*(1), 139-169. https://doi.org/10.1080/03066150902820354

Monteiro, C. A., Cannon, G., Levy, R. B., Moubarac, J. C., Louzada, M. L. C., Rauber, F., Khandpur, N., Cediel, G., Neri, D., Martinez-Steele, E., Baraldi, L. G., & Jaime, P. C. (2019). Ultra-processed foods: what they are and how to identify them. *Public Health Nutrition*, 22(5), 936-941. https://doi.org/10.1017/S1368980018003762

Mullainathan, S., & Shafir, E. (2013). *Scarcity: Why having too little means so much*. Macmillan. https://www.fdic.gov/analysis/cfr/consumer/2013/papers/scarcity-why-having-too-little-means-so-much.pdf

OECD. (2023). *Policies for the future of farming and food in the European Union*. OECD Publishing. https://www.oecd.org/en/publications/policies-for-the-future-of-farming-and-food-in-the-european-union_32810cf6-en.html

Oxfam. (2016). *Unearthed: Land, power and inequality in Latin America*. Oxfam. https://www.oxfam.org/en/research/unearthed-land-power-and-inequality-latin-america

Pachauri, S., & Spreng, D. (2011). Measuring and monitoring energy poverty. *Energy Policy, 39*(12), 7497-7504. https://doi.org/10.1016/j.enpol.2011.07.008

Piketty, T. (2014). *Capital in the twenty-first century*. Harvard University Press. https://www.researchgate.net/publication/283438439_Thomas_Piketty_2014_Capital_in_the_Twenty-First_Century_Translated_by_Arthur_Goldhammer_Cambridge_Massachusetts_Belknap_Press_of_Harvard_University_Press_2995_685_pp_hbk

Popkin, B. M., Corvalan, C., & Grummer-Strawn, L. M. (2020). Dynamics of the double burden of malnutrition and the changing nutrition reality. *The Lancet, 395*(10217), 65-74. https://doi.org/10.1016/S0140-6736(19)32497-3

Quesada, J., Hart, L. K., & Bourgois, P. (2011). Structural vulnerability. *Medical Anthropology, 30*(4), 339–362. https://pubmed.ncbi.nlm.nih.gov/21777121/

Quisumbing, A. R., Meinzen-Dick, R., Raney, T. L., Croppenstedt, A., Behrman, J. A., & Peterman, A. (2014). Closing the knowledge gap on gender in agriculture. In A. R. Quisumbing, R. Meinzen-Dick, T. L. Raney, A. Croppenstedt, J. A. Behrman, & A. Peterman (Eds.), *Gender in agriculture: Closing the knowledge gap* (pp. 3-27). Springer. https://doi.org/10.1007/978-94-017-8616-4_1

Quisumbing, A. R., Roy, S., & Waithanji, E. (2021). Women's empowerment in agricultural value chains. *Food Security, 13*, 1101–1124. https://link.springer.com/article/10.1007/s12571-021-01193-5?utm_source=chatgpt.com

© 2026 The Authors. Published under CC BY 4.0. | https://doi.org/10.66529/book.9786277945039.2026.ch13

Ravallion, M. (2016). *The economics of poverty*. Oxford University Press. https://www.academia.edu/27480851/Martin_Ravallion_The_Economics_of_Poverty_History_Measurement_and_Policy_Oxford_University_Press_2016_2333_

Resnick, D. (2020). COVID-19 lockdowns threaten Africa's vital informal urban food trade. In J. Swinnen & J. McDermott (Eds.), *COVID-19 and global food security* (pp. 73-74). Washington, DC: International Food Policy Research Institute (IFPRI).

Sarı, S. (2024). Macro dynamics of inflation in the Turkish economy. *Kocatepe İİBFD*, 26(2), 276–287. https://doi.org/10.33707/akuiibfd.1432536

Sarı, S. (2025). Macroeconomic determinants of food inflation in Türkiye: Empirical evidence from RALS-based time series analysis. *Business & Management Studies: An International Journal (BMJ), 13*(3), 1229–1239. https://doi.org/10.15295/bmij.v13i3.2618

Sen, A. (1981). *Poverty and famines: An essay on entitlement and deprivation*. Oxford University Press, 257 pp.

Shostak, S. (2023). Food and inequality. *Annual Review of Sociology, 49*, 359–378. https://www.annualreviews.org/content/journals/10.1146/annurev-soc-031021-112747

Slavchevska, V., Kaaria, S., & Taivalmaa, S. L. (2016). *Feminization of agriculture in the context of rural transformations: What is the evidence?* World Bank. https://openknowledge.worldbank.org/entities/publication/b8277c90-518e-5941-8e84-50881c11a426

Smith, L. C., & Haddad, L. (2015). Reducing child undernutrition: Past drivers and priorities for the post-MDG era. *World Development, 68*, 180-204. https://doi.org/10.1016/j.worlddev.2014.11.014

Spicker, P. (2007). The idea of poverty. *Journal of Social Policy, 36*(2), 307–323. https://archive.org/details/ideaofpoverty0000spic

Subramanian, S., & Deaton, A. (1996). The demand for food and calories. *Journal of Political Economy, 104*(1), 133-162. https://doi.org/10.1086/262020

Swinburn, B. A., Kraak, V. I., Allender, S., Atkins, V. J., Baker, P. I., Bogard, J. R., ... & Dietz, W. H. (2019). The global syndemic of obesity, undernutrition, and climate change: The Lancet Commission report. *The Lancet, 393*(10173), 791-846. https://doi.org/10.1016/S0140-6736(18)32822-8

Turner, C., Aggarwal, A., Walls, H., Herforth, A., Drewnowski, A., Coates, J., ... & Kadiyala, S. (2018). Concepts and critical perspectives for food environment research: A global framework with implications for action in low- and middle-income countries. *Global Food Security, 18*, 93-101. https://doi.org/10.1016/j.gfs.2018.08.003

UN Food Systems Summit. (2021). *Equity in food systems*. https://www.unfoodsystemshub.org/fs-summit-legacy/food-systems-summit-compendium/chapter-2-levers-of-change/equity-in-food-systems/en

UNCTAD. (2023). *Trade and development report 2023*. United Nations Conference on Trade and Development. https://unctad.org/system/files/official-document/tdr2023_en.pdf

United Nations Department of Economic and Social Affairs. (2021). *Population, food security, nutrition and sustainable development*. https://digitallibrary.un.org/record/3924543/files/PB_102.pdf

USDA. (2024). *National Food Security Law published - People's Republic of China*. United States Department of Agriculture, Foreign Agricultural Service. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=National%20Food%20Security%20Law%20Published_Beijing_China%20-%20People%27s%20Republic%20of_CH2024-0022.pdf

Wheeler, T., & von Braun, J. (2013). Climate change impacts on food security. *Science, 341*(6145), 508–513. https://doi.org/10.1126/science.1239402

World Bank. (2022a). *Climate change and food security*. https://thedocs.worldbank.org/en/doc/487f59dae4fce4903690d357136da5b1-0320052022/original/Food-Security-Update-LXVII-July-28-2022.pdf

World Bank. (2022b). *Pakistan floods 2022: Post-disaster needs assessment*. World Bank. https://documents1.worldbank.org/curated/en/099910201032325572/pdf/P17999100118d70520b99204e51eee8c9b2.pdf

World Bank. (2023). *Poverty and shared prosperity 2022*. World Bank. https://www.worldbank.org/en/publication/poverty-and-shared-prosperity

World Bank. (2024). *Lebanon poverty and equity assessment 2024 - Weathering a protracted crisis*. World Bank. https://documents1.worldbank.org/curated/en/099052224104516741/pdf/P176651-325da1d8-f439-48a7-ab6b-ae97816dd20c.pdf

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CHAPTER 14

Fragile and Conflict-Affected Contexts: Disruptions, Governance Failures, and Resilience Strategies

Fasiha Batool[1,*], Abdullah Hammad[1] & Zamah Bukhari[1]
[1]The University of Faisalabad, Faisalabad, Pakistan
Corresponding authors' email: fasihabatool.NBS@tuf.edu.pk

Abstract

Food security in fragile and conflict-affected contexts (FCACs) has emerged as one of the defining development and humanitarian challenges of the twenty-first century. In these environments, the interaction of armed conflict, political instability, economic crises, climate change, forced displacement, and weak governance creates complex and persistent vulnerabilities that undermine the four pillars of food security: availability, access, utilization, and stability. This chapter critically examines the multidimensional nature of food insecurity in FCACs through a systems-based and resilience-oriented perspective, integrating contemporary literature, conceptual frameworks, and global case studies from regions such as Yemen, Sudan, Syria, and the broader Middle East. The discussion highlights how conflict disrupts agricultural production, fragments markets, weakens institutions, and intensifies dependence on humanitarian assistance, while climate change and global supply chain disruptions further amplify existing risks. The chapter also explores the limitations of conventional emergency responses and argues for a transition from short-term humanitarian interventions toward long-term resilience-building strategies that strengthen local food systems, governance, climate-smart agriculture, social protection, and economic recovery. Emphasis is placed on the humanitarian-development-peace nexus and the importance of inclusive, locally driven approaches that enhance adaptive capacity and reduce structural dependence on external assistance. The chapter concludes that sustainable food security in FCACs cannot be achieved through food aid alone; rather, it requires integrated policies that address the root causes of fragility while promoting peace, institutional effectiveness, and resilient food systems capable of withstanding future shocks.

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1. Introduction

Food security has emerged as one of the most critical global challenges of the twenty-first century, particularly in fragile and conflict-affected contexts (FCACs). These settings are not only marked by political instability and weak governance but are also characterized by deep-rooted structural vulnerabilities that leave communities highly exposed to a wide range of shocks. Such shocks may be anthropogenic, including armed conflict and economic crises, or environmental, such as climate change, droughts, and floods. Within these complex and overlapping conditions, ensuring that populations have consistent access to safe, sufficient, and nutritious food becomes an increasingly difficult task.

According to the *State of Food Security and Nutrition in the World* (FAO *et al*., 2025), more than 735 million people worldwide experience chronic food insecurity, with a substantial proportion living in fragile and unstable regions. The strong association between instability and hunger suggests that contemporary food crises are not merely temporary disruptions but manifestations of deeper structural weaknesses that become entrenched within fragile systems.

The growing recognition of the relationship between nutrition and health has also reshaped contemporary debates on food security. The theme *Food as Medicine*, highlighted during the American Public Health Association symposium held in Washington, D.C., in November 2025, reflects an increasing appreciation of

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nutrition as an integral component of disease prevention and treatment. The rapid rise in the use of weight-loss medications has further encouraged the integration of nutrition into pharmacotherapy and broader healthcare strategies aimed at preventing and managing diet-related chronic diseases. The well-known Hippocratic principle, *"Let food be thy medicine and medicine be thy food,"* has gained renewed relevance in public health discourse. Yet, as Naumova (2026) argues, these ideas can appear detached from reality when millions of low-income citizens struggle to obtain basic food assistance, particularly during periods of severe institutional and economic disruption such as the longest government shutdown in United States history (United Nations High Commissioner for Refugees [UNHCR], 2024).

Global demographic and socioeconomic trends further intensify these concerns. Although the Green Revolution substantially increased agricultural production, nearly three billion people worldwide still cannot afford a healthy diet. Armed conflicts alone were responsible for 20 major food crises during the past year, affecting an estimated 140 million people, including populations experiencing famine conditions in Sudan and Gaza. During 2023–2024, the number of people facing the highest levels of food insecurity more than doubled, reversing much of the progress achieved in reducing hunger since 2000.

Naumova (2026) emphasizes that food security extends far beyond the production of adequate quantities of food. It is a multidimensional concept encompassing availability, access, affordability, utilization, and long-term stability. In fragile settings, these dimensions are deeply interconnected and often deteriorate simultaneously. Conflict may destroy agricultural infrastructure, economic crises reduce household purchasing power, and climate-related events undermine agricultural productivity. Consequently, food insecurity in FCACs cannot be understood or addressed through isolated interventions; rather, it requires an integrated and systems-based perspective.

This chapter critically examines food security in fragile and conflict-affected contexts through an exploration of its conceptual foundations, major drivers, systemic interconnections, illustrative case studies, and policy pathways for building long-term resilience.

Food security remains central to the global sustainable development agenda yet achieving it has become increasingly challenging in FCACs. Recent global assessments (FAO & WFP, 2025) indicate that ongoing conflicts and political instability, particularly across the Middle East, are likely to generate far-reaching humanitarian and economic consequences that extend well beyond the affected regions. Such uncertainty threatens food production, market stability, and international supply chains, thereby intensifying the risk of global food crises. The *Global Report on Food Crises* by FSIN and GNAFC (2025) estimated that nearly 295 million people experienced acute food insecurity in 2024, with conflict identified as the principal underlying driver. By weakening institutions, disrupting markets, and restricting access to essential resources, fragility significantly amplifies vulnerability.

The Middle East currently represents one of the world's most critical food security hotspots. Ongoing conflicts have disrupted food distribution networks and constrained humanitarian access, placing millions of people at risk of hunger in countries such as Yemen, Syria, Lebanon, and the Palestinian territories.

Historical experience also reminds us that food shortages often result not only from inadequate production but also from failures in governance and distribution. Families that endured the famines of the 1930s and the hardships of the Second World War frequently recall rationing systems for staple goods such as bread, sugar, and butter. Such experiences underscore an enduring lesson: scarcity is often a consequence of mismanagement as much as of insufficient supply. In contemporary industrial societies, the affordability of food has become a growing concern, prompting a reassessment of food security within the broader context of global nutritional transitions, widening social inequalities, and accelerating climate change.

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2. Conceptual Framework for Food Security

2.1. The Four Pillars of Food Security

Food security is founded on four interrelated pillars, each of which plays a fundamental role in ensuring that populations can obtain adequate and nutritious food. In fragile and conflict-affected settings, however, each of these pillars is subject to significant disruption.

Food Availability

Food availability refers to the physical presence of sufficient food within a country or region. It depends on domestic agricultural production, food imports, and, where necessary, humanitarian food assistance. Under stable conditions, efficient farming systems and well-functioning supply chains help maintain adequate food supplies. In fragile settings, however, agricultural production is frequently interrupted.

For example, ongoing conflicts in countries such as Sudan and Syria have destroyed farmland, irrigation networks, and storage facilities. Persistent insecurity often forces farmers to abandon their land, resulting in substantial declines in agricultural output (FAO, 2023). At the same time, disruptions to supply chains and economic restrictions limit access to essential agricultural inputs, including seeds, fertilizers, and machinery. As a result, many fragile states become increasingly dependent on food imports and humanitarian assistance, leaving them highly exposed to fluctuations in global markets and external supply conditions.

Food Access

Food access concerns the ability of individuals and households to obtain food both economically and physically. Even when food is available in local markets, many people may lack the financial means or safe physical access required to acquire it.

Inflation and unemployment present major barriers in fragile economies. During periods of economic instability, food prices often rise more rapidly than household incomes, significantly reducing purchasing power. The World Bank (2024) reports that households in fragile states may spend more than 60% of their total income on food, leaving limited resources for other essential needs such as healthcare and education.

Physical access to food is also constrained in conflict zones. Damaged roads, destroyed infrastructure, and security threats often prevent people from reaching markets. In some areas, including Gaza, blockades and military restrictions further limit the movement and availability of essential food supplies.

Food Utilization

Food utilization refers to the body's ability to effectively use consumed food, a process influenced by food quality and safety, nutritional diversity, water and sanitation conditions, and access to healthcare. In fragile contexts, poor living conditions severely undermine this pillar.

Limited access to clean water and adequate sanitation increases the incidence of diseases such as diarrheal infections, which impair nutrient absorption. Simultaneously, weak healthcare systems reduce the capacity to diagnose and treat malnutrition. Diets in conflict-affected regions are frequently dominated by staple foods such as wheat or rice and often lack the diversity required to meet micronutrient needs. Consequently, deficiencies in essential vitamins and minerals are common.

Children and pregnant women are particularly vulnerable. According to (United Nations Children's Fund, 2023; United Nations Development Program, 2024), millions of children living in fragile contexts experience wasting and stunting, conditions that have profound and lasting effects on physical growth, cognitive development, and future economic productivity.

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Food Stability

Food stability refers to the ability of food systems to provide reliable access to adequate food over time. In fragile settings, this stability is repeatedly undermined by conflict, economic crises, and environmental shocks.

A region may enjoy sufficient food supplies during one season only to face severe shortages in the next because of drought, armed conflict, or market disruption. Such uncertainty creates chronic food insecurity, where households cannot rely on stable or predictable access to food and remain perpetually vulnerable to sudden crises.

2.2. Expanding the Concept: Agency and Sustainability

Contemporary understandings of food security have evolved beyond the traditional four-pillar framework to include two additional dimensions: agency and sustainability (HLPE, 2020).

Agency refers to the capacity of individuals and communities to make informed choices about the production, acquisition, and consumption of food. In fragile contexts, this capacity is often severely constrained. Many households become heavily dependent on humanitarian assistance and have limited control over their own food systems and livelihoods.

Sustainability concerns the ability of food systems to meet present needs without compromising the capacity of future generations to meet theirs. In FCACs, however, immediate survival frequently takes precedence over long-term sustainability. This can encourage unsustainable practices, including overexploitation of land, depletion of natural resources, and environmentally damaging coping strategies that further undermine future resilience.

3. Understanding Fragility and Conflict-Affected Contexts

Fragility is a multidimensional concept that extends well beyond the presence of armed conflict. It reflects systemic weaknesses across political, economic, social, and environmental domains that reduce a society's ability to manage risks and respond effectively to crises.

3.1. Political Fragility

Political fragility is characterized by weak governance, limited institutional capacity, and corruption. In many fragile states, governments lack the ability to formulate and implement effective food security policies or regulate markets efficiently.

Weak governance often results in unequal food distribution, leaving certain regions or population groups underserved. Corruption can further divert scarce resources away from vulnerable communities, compounding existing food insecurity and weakening public trust in institutions.

3.2. Economic Fragility

Economic instability is a major contributor to food insecurity. High inflation, unemployment, and currency depreciation reduce household purchasing power and limit access to necessities. In periods of hyperinflation, the prices of staple food commodities can increase dramatically within a short period, making them unaffordable for large segments of the population and pushing vulnerable households deeper into poverty.

3.3. Social Fragility

Social fragility encompasses inequality, social exclusion, marginalization, and the absence of effective social protection systems. The impacts are often unevenly distributed, with women, children, and rural populations bearing a disproportionate share of the burden. Women, for example, frequently face barriers to land ownership, credit, and productive resources, reducing both their capacity to produce food and their ability to secure adequate nutrition for their households.

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3.4. Environmental Fragility

Environmental fragility reflects the susceptibility of ecosystems and livelihoods to climate-related stocks such as droughts, floods, desertification, and other forms of environmental degradation. The World Bank (2025) notes that fragile states are among those most severely affected by climate change, despite contributing the least to global greenhouse gas emissions.

The interaction between environmental stress and existing political and economic vulnerabilities further intensifies food insecurity, highlighting the need for integrated approaches that address both climate resilience and broader development challenges.

4. Drivers of Food Insecurity in Fragile and Conflict-Affected Contexts

4.1. Armed Conflict and Violence

Armed conflict remains the single most significant driver of food insecurity in fragile and conflict-affected contexts (FCACs). Its effects extend across the entire food system, disrupting production, processing, transportation, markets, and household consumption. In conflict zones, insecurity often forces farmers to abandon agricultural land, reducing cultivated areas and lowering food output. Damage to roads, irrigation infrastructure, storage facilities, and local markets interrupts supply chains and limits the movement of agricultural goods. In many cases, conflict also results in the destruction or looting of crops, livestock, and farming equipment, further undermining rural livelihoods.

Beyond these direct impacts, prolonged insecurity discourages investment in agriculture and market development, contributing to declining productivity and rising food prices. According to the FAO & WFP (2025), nearly 70% of the world's hungry population is affected by conflict, highlighting the close relationship between violence and chronic food insecurity.

4.2. Geopolitical Tensions and Global Food Markets

In an increasingly interconnected world, the consequences of regional conflicts often extend far beyond national borders. Modern geopolitical crises disrupt global commodity markets, alter trade flows, and expose the vulnerabilities of import-dependent countries.

The Russia-Ukraine conflict offers a clear example of these cascading effects. As two of the world's major exporters of wheat, sunflower oil, and fertilizers, disruptions in production and exports from the region have contributed to higher food prices and supply shortages across international markets. Countries in Africa and the Middle East, which rely heavily on imported cereals, have been particularly affected. Similarly, the humanitarian emergencies in Gaza and Sudan illustrate how localized conflicts can trigger wider regional food crises, demonstrating the global implications of political instability.

4.3. Climate Change as a Threat Multiplier

Climate change does not act in isolation; rather, it amplifies existing social, economic, and political vulnerabilities. Rising temperatures, changing rainfall patterns, prolonged droughts, and increasingly frequent floods reduce agricultural productivity and intensify food insecurity in already fragile settings.

Prolonged droughts across East Africa have caused widespread crop failures and livestock losses, while recurrent flooding in South Asia has destroyed agricultural land and displaced millions of people. These climate-induced disruptions reduce food availability, increase market prices, and deepen livelihood insecurity, particularly for populations that depend directly on agriculture for income and subsistence.

4.4. Economic Shocks and Inflation

Economic instability represents another major challenge to food security in FCACs. Global crises such as the COVID-19 pandemic, coupled with inflationary pressures and disruptions in international trade, have significantly increased the cost of food. Rising prices disproportionately affect low-income households, which often spend the largest share of their income on food. As purchasing power declines, vulnerable

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populations are forced to reduce both the quantity and quality of their diets, increasing the risk of malnutrition and poverty.

4.5. Forced Displacement and Livelihood Loss

Conflict and environmental disasters frequently result in large-scale displacement, serving people from their land, employment, and traditional livelihood systems. Refugees and internally displaced people often have limited opportunities for formal employment and become heavily dependent on humanitarian assistance for survival. Displacement not only weakens household resilience but also places additional pressure on host communities and local food systems.

4.6. Weak Governance and Institutional Failure

Institutional weakness and poor governance significantly constrain the ability of states to prevent or respond effectively to food crises. Limited administrative capacity, corruption, weak policy implementation, and inadequate disaster preparedness often result in inefficient resource allocation and delayed interventions. In many FCACs, governance failures magnify the impacts of conflict and climate shocks, leaving vulnerable populations with limited access to essential support.

5. Systemic Vulnerabilities and Human Development Impacts

Food insecurity in fragile settings emerges from the interaction of multiple interconnected risks rather than from a single cause. Climate change may trigger droughts that reduce agricultural production, which in turn raises food prices and contributes to economic hardship and social unrest. Conflict further disrupts markets and agricultural activities, creating a reinforcing cycle of instability and vulnerability.

The consequences extend well beyond hunger. Food insecurity undermines several dimensions of human development:

- **Health:** Increased malnutrition, disease burden, and poor physical and cognitive development.
- **Education:** Reduced school attendance and learning outcomes as children are forced to work or households cannot meet educational expenses.
- **Economic Development:** Declining productivity, loss of livelihoods, and rising poverty.
- **Gender Equality:** Women and girls often bear a disproportionate burden through unequal access to resources, increased caregiving responsibilities, and reduced economic opportunities.

6. Case Studies from Fragile Contexts

Yemen

Years of protracted conflict have created one of the world's most severe humanitarian emergencies. Agricultural production and food distribution systems have been severely disrupted, leaving millions of people dependent on humanitarian food assistance.

Sudan

Continuing violence and political instability have undermined farming activities and rural livelihoods. Population displacement and market disruption have contributed to escalating levels of acute food insecurity.

Syria

The combined effects of prolonged armed conflict and recurrent drought have devastated agricultural production and weakened food supply chains, creating persistent food insecurity across the country.

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7. Global Food System Interdependencies

Contemporary food systems are deeply interconnected, meaning that disruptions in one region can have significant consequences elsewhere. Fragile and conflict-affected countries are particularly vulnerable because many depend heavily on imported staple commodities rather than domestic production.

Many low-income and fragile states rely on imports of wheat, rice, and maize, creating structural dependence on international markets. Consequently, global supply disruptions or sudden price increases can rapidly translate into domestic food shortages. The Russia-Ukraine conflict demonstrated this vulnerability, as interruptions in exports of wheat, sunflower oil, and fertilizers generated substantial price increases across North Africa and the Middle East.

Economic fragility further compounds these challenges. Many FCACs possess limited foreign exchange reserves, restricting their capacity to finance food imports during periods of economic stress. Currency depreciation raises import costs even further, creating a situation where food may be available globally but remains inaccessible to vulnerable populations.

Dependence on international supply chains also exposes these countries to external shocks such as pandemics, trade restrictions, or maritime disruptions. Weak infrastructure, including inadequate storage facilities, transport networks, and port systems, limits their capacity to absorb such shocks. Ultimately, excessive reliance on external markets reduces food sovereignty and underscores the importance of strengthening local agricultural production and domestic food systems.

8. Humanitarian Response: Opportunities and Limitations

Humanitarian interventions play an indispensable role in addressing food crises in fragile contexts, particularly during emergencies. Food assistance programs, including direct food distribution and cash-based transfers, provide immediate relief and help prevent famine and starvation. In countries such as Yemen, large-scale humanitarian operations have enabled millions of people to survive despite ongoing conflict.

Cash transfer programs have gained increasing attention because they provide households with greater flexibility while simultaneously supporting local markets and businesses. Nevertheless, humanitarian interventions alone cannot provide a durable solution to chronic food insecurity.

Long-term dependence on aid may weaken local agricultural systems and create reliance on external assistance. Funding shortfalls continue to undermine the effectiveness of humanitarian programs, leaving many vulnerable populations underserved. In conflict zones, political barriers, insecurity, and logistical constraints often prevent aid from reaching those most in need, as observed in Gaza and Sudan.

Recent policy thinking increasingly emphasizes a transition from emergency response toward resilience building. This approach prioritizes investment in local agriculture, infrastructure, livelihood restoration, and institutional strengthening to reduce long-term dependence on humanitarian assistance. Achieving this transition, however, requires coordinated efforts among governments, international organizations, and local communities.

9. Building Resilient Food Systems: Policy and Strategic Responses

Addressing food insecurity in fragile settings requires a multidimensional strategy that combines immediate humanitarian support with long-term structural reforms.

9.1. Climate-Smart Agriculture

Climate-smart agriculture promotes farming practices that enhance productivity while improving resilience to environmental stress. The adoption of drought-tolerant crop varieties, efficient irrigation technologies, and sustainable land management practices can help maintain agricultural output under changing climatic conditions. In drought-prone regions of Africa, for example, farmers are increasingly adopting crops that require less water and are better adapted to climatic variability.

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9.2. Strengthening Governance and Institutions

Strong institutions are essential for effective food system management. Governments must establish policies that support agricultural development, regulate markets, and ensure equitable food distribution. Measures aimed at reducing corruption and improving transparency are equally important, as institutional accountability directly influences the success of food security interventions.

9.3. Economic Stability and Livelihood Support

Food security and economic resilience are closely linked. Policies that promote employment, stabilize inflation, and strengthen household incomes improve people's ability to access food. Livelihood restoration programs and vocational training initiatives can help displaced populations rebuild economic security while reducing dependence on external aid.

9.4. Peacebuilding and Conflict Resolution

Sustainable food security cannot be achieved without peace. Armed conflict disrupts every component of the food system, from agricultural production to market access. Efforts to resolve conflicts, strengthen political stability, and promote inclusive governance are therefore fundamental to restoring resilient food systems.

9.5. Social Protection Systems

Social protection measures, including cash transfers, food subsidies, and school feeding programs, provide an essential safety net for vulnerable populations. Beyond improving nutrition, school feeding initiatives contribute to higher school attendance and generate long-term benefits for human capital development.

10. Towards Sustainable and Resilient Food Systems

Transforming food systems in FCACs requires moving beyond reactive crisis management toward proactive, resilience-oriented strategies. A sustainable food system not only ensures food security but also protects environmental resources and promotes social equity.

Key priorities include expanding local food production, reducing excessive dependence on imports, promoting sustainable agricultural practices, and strengthening community participation in food system governance. Investments in rural infrastructure, such as roads, irrigation networks, and storage facilities, can reduce post-harvest losses and improve market access. Equally important is empowering local farmers and communities to participate actively in the design and implementation of food security initiatives.

11. Discussion: Rethinking Food Security in Fragile Contexts

Despite considerable international efforts, food insecurity in fragile and conflict-affected settings continues to worsen, suggesting that current approaches remain insufficient. A major limitation is the continued reliance on humanitarian assistance as the primary response mechanism. While emergency aid is indispensable, it often addresses symptoms rather than the structural causes of food insecurity. Long-term resilience requires sustained investment in local agricultural systems, institutional development, and community capacity building.

The evidence increasingly supports a system-based understanding of food security. Rather than focusing solely on food availability, contemporary scholarship emphasizes the interdependence of access, utilization, stability, resilience, and sustainability (FAO, 2023). Maxwell & Slater (2003) argue that food security should be viewed as a dynamic process shaped by political, economic, environmental, and social forces. In FCACs, instability weakens all four traditional pillars simultaneously, requiring flexible and adaptive policy responses.

Current research consistently identifies conflict as the leading global driver of hunger. As of 2022, approximately 735 million people were experiencing hunger worldwide, representing an increase of 122 million people compared with the pre-pandemic period. According to UNHCR (2024) conflict accounts for

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69% of global hunger, while approximately 20% of Africa's population faces hunger, with countries such as South Sudan, Burundi, and Malawi among the most severely affected. Forecasts suggest that, if current conflicts continue, global food prices could increase by 15–20% during the first half of 2026.

Recent analyses (FSIN & GNAFC, 2025; World Bank, 2024; 2026) further emphasize that prolonged conflicts create entrenched and chronic food insecurity, making recovery increasingly difficult. Countries such as Yemen, Syria, and Lebanon illustrate how armed conflict, economic instability, and institutional weakness combine to produce long-lasting food crises.

Governance also emerges as a central determinant of resilience. Weak institutional capacity often results in poor policy implementation, corruption, resource misallocation, and inadequate crisis management. According to the World Bank (2024, 2026), strengthening governance structures and institutional effectiveness is fundamental for building resilient food systems and improving the outcomes of both humanitarian and development interventions.

Market disruptions represent another critical challenge. Conflict fragments supply chains, increase transaction costs, and generate price volatility that disproportionately affects poor households. At the same time, humanitarian systems face persistent constraints related to funding gaps, security concerns, and restricted access. Increasingly, literature advocates integrated approaches that combine humanitarian action, long-term development, and peacebuilding within a single policy framework.

Theoretical perspectives such as Systems Theory, Resilience Theory, and the Political Economy of Food Security provide valuable lenses for understanding these complex interactions. These frameworks recognize food systems as interconnected networks in which agricultural production, markets, governance, infrastructure, and social institutions continuously influence one another. Disruptions in any one component, whether through conflict, market failure, governance breakdown, or logistical constraints, can rapidly cascade across the entire system.

The global implications of ongoing conflicts further reinforce the urgency of resilience-based approaches. Disruptions to maritime trade routes, including strategic chokepoints such as the Strait of Hormuz, have increased transportation costs and delayed food imports. It has been estimated that a one-fifth increase in global food prices could push an additional 5 million people in Arab countries into food crisis conditions. Countries such as Yemen and Syria, already heavily dependent on food assistance, remain particularly vulnerable to such external shocks.

The Middle East conflict has also generated broader consequences for developing economies. According to the Food and Agriculture Organization (FAO & WFP, 2025), the conflict has increased global food prices by 2.4%, driven largely by rising energy costs and disruptions in fertilizer supplies. The resulting food price inflation, fertilizer shortages, economic instability, and increasing poverty threaten food security across many low-income countries. These trends highlight the need for diversified food import strategies, investments in local climate-resilient agriculture, stronger social safety nets, and greater regional cooperation to stabilize food markets and strengthen resilience.

Ultimately, conventional food security approaches that focus primarily on production and supply are insufficient for FCACs. A broader systems-oriented perspective that integrates governance, resilience, social protection, local capacity building, and sustainable development is required to address the complex realities of food insecurity in fragile environments.

12. Policy Implications

The analysis presented in this chapter suggests several key policy priorities for strengthening food security in fragile and conflict-affected contexts:

1. Invest in long-term resilience-building initiatives alongside emergency humanitarian responses.
2. Strengthen governance structures and institutional capacity to improve policy implementation and crisis management.

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3. Promote integrated humanitarian-development-peace approaches that address both immediate needs and structural vulnerabilities.

4. Support localized and climate-resilient food systems that reduce dependence on external supply chains and enhance community self-reliance.

13. Conclusion

Food insecurity in fragile and conflict-affected contexts is not simply the consequence of inadequate food production but the outcome of deeply interconnected political, economic, social, and environmental failures. As this chapter has demonstrated, armed conflict, governance breakdown, market disruptions, climate change, forced displacement, and global economic shocks interact to undermine every dimension of food security, creating cycles of vulnerability that are difficult to reverse. The evidence from countries such as Yemen, Sudan, Syria, and other conflict-affected regions illustrates that prolonged crises weaken agricultural systems, erode livelihoods, disrupt supply chains, and increase dependence on external humanitarian assistance.

A central insight emerging from this analysis is that conventional, production-oriented or emergency-driven approaches are insufficient to address the structural roots of food insecurity in FCACs. While humanitarian aid remains indispensable for saving lives during acute crises, it cannot substitute for long-term investments in resilient local food systems, effective governance, and sustainable livelihoods. Durable solutions require a shift from reactive crisis management toward proactive resilience-building strategies that integrate climate-smart agriculture, social protection mechanisms, institutional strengthening, market stabilization, and peacebuilding initiatives. Equally important is the adoption of a systems-thinking perspective that recognizes the interdependence of food systems, governance structures, environmental conditions, and global supply chains.

Ultimately, rethinking food security in fragile settings demands a paradigm shift from short-term relief to transformative resilience. Strengthening local agricultural capacity, reducing excessive dependence on imports, improving institutional accountability, and fostering international cooperation through the humanitarian-development-peace nexus are essential for sustainable progress. Food security should therefore be viewed not only as a humanitarian imperative but also as a cornerstone of human development, social stability, and lasting peace. Without coordinated global and local action to address the underlying drivers of fragility, the burden of hunger and malnutrition in conflict-affected regions will continue to grow, threatening both regional and global security in the years ahead.

References

FAO. (2023). *The state of food security and nutrition in the world 2023*. Food and Agriculture Organization. https://openknowledge.fao.org/server/api/core/bitstreams/1f66b67b-1e45-45d1-b003-86162fd35dab/content

FAO, IFAD, UNICEF, WFP & WHO. (2025). *The state of food security and nutrition in the world 2025: Addressing high food price inflation for food security and nutrition*. Food and Agriculture Organization. https://doi.org/10.4060/cd6008en

FAO & WFP. (2025). *Hunger hotspots: FAO–WFP early warnings on acute food insecurity, November 2025 to May 2026 outlook*. Food and Agriculture Organization. https://doi.org/10.4060/cd7310en

FSIN & GNAFC. (2025). *2025 global report on food crises*. Food Security Information Network, & Global Network Against Food Crises. https://www.fsinplatform.org/grfc2025

HLPE. (2020). *Food security and nutrition: Building a global narrative towards 2030*. High Level Panel of Experts on Food Security and Nutrition. https://openknowledge.fao.org/server/api/core/bitstreams/8357b6eb-8010-4254-814a-1493faaf4a93/content

Maxwell, S., & Slater, R. (2003). Food policy old and new. *Development Policy Review*, *21*(5-6), 531-553. https://doi.org/10.1111/j.1467-8659.2003.00222.x

Naumova, E. N. (2026). From measurement to meaning: Rethinking food security through resilience-based and systems-oriented approaches. *Journal of Public Health Policy*, 1-6. https://doi.org/10.1057/s41271-025-00609-2

United Nations Children's Fund. (2023). *Child malnutrition estimates*. https://data.unicef.org/resources/jme/

United Nations Development Program. (2024). *Human development report 2023/2024*. https://hdr.undp.org/system/files/documents/global-report-document/hdr2023-24reporten.pdf

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United Nations High Commissioner for Refugees. (2024). *Global trends: Forced displacement in 2024*. https://www.unhcr.org/sites/default/files/2025-06/global-trends-report-2024.pdf

World Bank. (2024). *Food security update*. Retrieved June 30, 2026, from https://www.worldbank.org/en/topic/agriculture/brief/food-security-update

World Bank. (2025). *Fragility, conflict, and violence report*. https://www.worldbank.org/ext/en/topic/fragility-conflict-and-violence

World Bank. (2026). *Global economic prospects, January 2026*. https://doi.org/10.1596/978-1-4648-2267-4

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CHAPTER 15

Comparative Policy Lessons: What Works, Where, and Under What Conditions in Food System Governance

Burhan Ahmad[1], Muhammad Amjed Iqbal[2,*], Muhammad Hafeez[1], Ahras Rashid[1] & Ayesha Noreen[1]
[1]Institute of Business Management Sciences, University of Agriculture, Faisalabad, Pakistan.
[2]Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad, Pakistan
Corresponding authors' email: amjed.iqbal@uaf.edu.pk

Abstract

Drawing on comparative experiences from developing countries, this chapter examines how food system governance shapes food security and why policy outcomes depend on the interaction of institutions, markets, political economy, and environmental conditions rather than agricultural production alone. It presents a conceptual framework linking policy instruments, intermediary systems, and structural constraints to key food security outcomes, including availability, access, nutrition, stability, and resilience. Evidence from initiatives such as Brazil's *Bolsa Família*, Indonesia's subsidy reforms, Vietnam's trade liberalization, and climate-smart agricultural practices demonstrates that policy success is highly context dependent and closely tied to institutional capacity and adaptive governance. The chapter identifies policy coherence, strong institutions, political feasibility, integrated planning, and continuous learning as the principal drivers of effective food system transformation. It further highlights the need to balance critical trade-offs between efficiency and equity, productivity and sustainability, and short-term relief and long-term resilience. The chapter concludes that there is no universal blueprint for achieving food security; instead, durable progress requires context-specific, flexible, and evidence-based policy frameworks that treat food systems as interconnected and dynamic systems.

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1. Introduction

In the past few decades, food security policy in developing countries has evolved. Initial approaches largely emphasized national food self-sufficiency, input intensification and increases. While these methods assisted in increasing aggregate food supply, they did not address the problems of chronic hunger, malnutrition, inequity and vulnerability (Barrett, 2010; Pinstrup-Andersen, 2013). This limitation promoted a gradual shift towards a broader understanding of food security as a complex outcome encompassing access, consumption, stability, and resilience.

Food security thought evolution has been influenced by core concepts such as Sen's entitlement approach, which emphasized that food security depends not only on availability, but also people's ability to command resources (Sen, 1983). The concept has been further broadened to include nutrition, sustainability, and food systems transformation in subsequent research by the High-Level Panel of Experts (HLPE, 2020) and international organizations such as the Food and Agriculture Organization. This development reflects an increasing recognition that the determinants of food security outcomes are a complex interaction of environmental, institutional and finance factors. New challenges exist in contemporary food networks.

Climate change is making extreme weather events more frequent and intense, so it is affecting supply chains and production (IPCC, 2022). Scarcities of resources, notably water and energy, are becoming critical issues in many regions. At the same time, patterns of demand and market structures are being transformed through rapid urbanization, population growth and globalization. Flexibility and adaptability are also highlighted by

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recent global events (pandemic and geopolitical) that have exposed vulnerabilities in food systems (FAO, 2021; World Bank, 2022).

In this environment, food security has evolved from being a sectoral issue limited to agriculture to a system governance problem that requires multiple policy areas and levels of government collaborations. This chapter examines the success, location and circumstances of food system management. It aims to provide a basis for developing effective and context-specific policies through a synthesis of various countrywide experiences and policy developments.

2. Unified Analytical Framework for Comparative Analysis

Understanding the differences in policy results across countries requires the application of a systems-based analysis approach that records the interactions between institutions, policies, and situational limitations. Fundamentally, food system performance may be seen as:

Food System Outcomes = f (Policy Mix × Institutions × Incentives × Resources × Climate × Capacity)

This formulation builds on institutional economics (North, 1990) and political economy perspectives (Acemoglu & Robinson, 2012), emphasizing that policy effectiveness depends not only on design but also on the systems through which policies are implemented.

The framework can be understood as a multi-layered system as depicted in figure 15.1. At the top of figure 15.1 is the policy mix, which includes subsidies, trade, social protection and climate policies. These mechanisms reflect the priorities of government that affect various aspects of food systems. But policies don't work in a vacuum or independently. Rather, policies are delivered through mediated systems such as data systems, markets, political economy and institutions. Institutions determine how well policies can be implemented and held accountable; markets influence resource allocation and price signals; political economy factors shape policy development and continuity; and data systems support targeting, monitoring and learning. These systems significantly affect policy effectiveness.

The constraints of this layer include financial constraints, resource interdependencies (water-energy-food nexus) and climate risks. These restrictions influence the feasibility, sustainability and trade-offs associated with policy measures. For example, water shortage may restrict efforts to boost agricultural productivity; financial constraints may limit the size of subsidies. The interaction of these elements produces outcomes in food systems which are complex. They include availability (supply), access (affordability), nutrition (diet quality), stability (consistency over time) and resilience (ability to withstand shocks). This multidimensionality is a reminder that it is important to employ integrated policy instruments.

Figure 15.1 Conceptual Structure of the Framework
Source: FAO (2021), HLPE (2020), and IFPRI frameworks.

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The central implication of this framework is that policy effectiveness is conditional. Identical policy instruments can produce very different outcomes depending on institutional capacity, market conditions, and contextual constraints. This insight provides the foundation for the comparative analysis that follows.

3. Comparative Policy Patterns Across Domains

There are several key themes that cut across policies and sectors across the Globe described as follows:

3.1. Policy Coherence and Coordination

Policy harmony is a common finding. Fractured rules often create conflicting incentives, causing efficiency loss. Subsidies, for example, may encourage production growth; but tariffs distort price signals and efficiency. Integrated approaches which combine agricultural, trade, social protection and environment policy objectives are thus more likely to deliver sustainable outcomes (FAO, 2021).

3.2. Organizations and Political Economy

The capacity of institutions is an important component of politics. Inefficient implementation, corruption and wastage are associated with weak institutions even when policy intentions are good. This result is consistent with the broader literature on institutions and growth emphasizing the role of the political system in explaining economic performance (North, 1990). The political economy even influences policy choices and persistence. Surviving policies are oftentimes not efficient but politically expedient. Therefore, reform processes need to consider interests and distributions (Acemoglu & Robinson, 2012).

3.3. Markets and Motivations

Market structure and functioning are key to policy outcomes. Efficient markets facilitate price signaling, investment and resource allocation. In turn, market distortions (like export bans or price controls) can worsen fluctuations and incentives for suppliers (Anderson & Martin, 2012).

Limits on Resources and Climate Resources and climate change are increasingly important in food security policy. The growing importance of the water-energy-food nexus highlights the importance of integrated planning that accounts for resource interdependencies (FAO, 2016). At the same time, climate change requires flexible, rather than fixed, policies.

4. Evidence from Access, Nutrition, and Social Protection

One key finding from the studies is that food security can't be achieved simply by boosting food supply. Access, diet and equity are also important aspects. Social protection programs have been relatively successful in improving food access. Brazil's Bolsa Família is an example of how effective cash transfer programs can reduce poverty and enhance food security outcomes when supported by strong administrative and communications systems (Lindert *et al*., 2007; World Bank, 2018).

The other major area of innovation is nutrition-sensitive policies. These policies connect food production to nutrition outcomes, thus fostering various food systems and improved nutrition. There is evidence that such integrated approaches are more effective than production-focused approaches (HLPE, 2020).

5. Policy Variation and Contextual Diversity

Cross-country studies reveal that policies have differential outcomes. Differences in institutional strength, resource endowments and vulnerability to risks across countries lead to differences in policy needs and outcomes. For instance, market-oriented policy reforms have been very effective in countries like Vietnam where strong institutions and integration in the global market have led to agricultural growth and export competitiveness. On the other hand, vulnerable settings like South Sudan have significant disruption in governance and markets and require hybrid strategies that combine long-term strategies to build resilience with humanitarian aid (World Bank, 2022). These differences underscore the importance of customizing approaches to match specific local contexts rather than adopting one-size-fits-all approaches.

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6. What Works: Comparative Evidence

As presented in Table 15.1, the comparative evidence reveals that a range of policy options have been successful in specific contexts. Cash transfer programs have consistently increased food supply in countries with good governance and information systems. Brazil's Bolsa Família is a case study; failure in less well-off countries highlight the need for governance and IT infrastructure (Gentilini, 2014).

Table 15.1 Policy Effectiveness Across Contexts

Policy Type	Works Where	Example	Fails Where	Key Conditions
Cash Transfers	Strong data systems	Brazil	Weak systems	Digital infrastructure
Subsidy Reform	Political commitment	Indonesia	Political resistance	Gradual reform
Trade Liberalization	Integrated markets	Vietnams	Fragile systems	Institutional regulation
Climate-Smart Agriculture	Strong support systems	Kenya	Resource-poor areas	Extension services
Adaptive Policies	Flexible systems	Bangladesh	Rigid systems	Learning capacity

Source: Gentilini (2014); FAO (2016); Anderson & Martin (2012); World Bank (2016, 2018); IPCC (2022).

Subsidy reforms have been most successful with gradual changes and political consensus, as in Indonesia. However, interest groups have blocked change in other cases, such as India (Gulati & Banerjee, 2015). In countries with well-developed markets, such as Vietnam, trade liberalization has improved agricultural productivity; but it has posed a risk in less developed settings. In countries such as Kenya, climate-smart agriculture has boosted resilience; however, adoption is still limited in resource poor settings such as Niger (Bryan *et al*., 2013; FAO, 2016). Adaptive policy has been particularly effective in climate risky settings. Bangladesh's investments in early warning systems and adaptable planning demonstrate how adaptive governance can reduce vulnerability (Saha *et al*., 2016).

7. Where Policies Work: Context Typology

One must have a contextual view to grasp where policies fit. Table 15.2 offers a classification connecting policy appropriateness to various situations. Though they present coordination issues, high-capacity systems can carry out sophisticated, combined plans. Though they may be subject to inefficiencies, low-capacity systems call for easier treatments. Adaptive policies help climate-vulnerable systems; resource-limited ones need integrated strategies to control the water–energy–food nexus. Hybrid approaches combining humanitarian and development efforts are called for in fragile situations.

Table 15.2 Context-Based Policy Suitability

Context Type	Example Country	Suitable Policy	Risk
High Capacity	Brazil	Integrated reforms	Complexity
Low Capacity	Afghanistan	Simple transfers	Leakage
Climate Vulnerable	Bangladesh	Adaptive policies	Data gaps
Resource-Constrained	Jordan	Nexus planning	Coordination failure
Fragile State	South Sudan	Hybrid models	Governance breakdown

Source: FAO (2016, 2021); World Bank (2022); Saha *et al*. (2016).

8. Conditions for Policy Success

This chapter identifies several key factors for policy success. Key elements include capabilities, political economy, finances, markets, climate risks, and data. Rwanda, Indonesia, Vietnam, Ethiopia and India's experiences illustrate the impact of these factors (Gilligan *et al*., 2009; Muralidharan *et al*., 2016; World Bank, 2019).

9. Cross-Cutting Insights

The synthesis of country experiences offers several cross-country insights about the nature of food systems and policy. These insights capture general principles in the way food systems operate and form the basis for designing more effective and tailored policies.

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First, policy coherence is critical to success. The policy spaces for food systems are the connected policy domains of agriculture, trade, health, environment and social protection. Separate policy design and implementation in these spaces can result in conflicting priorities. For example, agricultural input subsidies to stimulate production can increase supply, but when combined with trade distortions or market inefficiencies, this can lead to distortions and inefficiencies. Similarly, agricultural policies cannot improve nutrition outcomes without health, education and food market policies. For instance, evidence from Brazil highlights the impact of integrated policies (social protection, agriculture and nutrition) in delivering more sustainable and inclusive outcomes which leads to the conclusion that food security requires integrated rather than agricultural-only policies (HLPE, 2020; FAO, 2021).

The second lesson is that the design of policies is constrained by the capacity of institutions. Across contexts, the effectiveness of policy is more about the institutional capacity to implement, monitor and adjust to policy initiatives. Good institutions can focus on policies, reduce leakages and enhance accountability, while bad institutions can cause inefficiencies and unintentional consequences. The agricultural revolution in Rwanda, for example, illustrates how improved management capacity and governance play a key role in achieving policy goals, while similar policies have failed in other less institutionalized countries This finding is consistent with the recent institutional economics literature that emphasizes the importance of "rules of the game" (North, 1990).

Third, political economy factors play a key role in policy choices and outcomes. Policies are not delivered in a vacuum but are influenced by the interests of various stakeholders, elections and egalitarian considerations. For instance, subsidies are inefficient but are implemented due to their benefits for politically influential groups. Attempts to reform such policies can be difficult, as with India's fertilizer subsidy. By comparison, Indonesia's reforms highlight the need to enhance political acceptance through gradual reforms and compensation measures (Acemoglu & Robinson, 2012). These examples show that policy formulation needs to consider political incentives and building support, not simply technical considerations.

Fourth, research shows integrated policies are more effective than isolated policies. There are many determinants of food security, including production, marketing, income and nutrition. Stand-alone interventions are likely to be short-lived. For example, increased productivity without improved market access may not necessarily lead to higher incomes, while more social protection without addressing productivity bottlenecks can lead to inflation. Countries that have adopted a more comprehensive approach that also includes agriculture, social protection and market reforms have done better. An example of such a program is the Productive Safety Net Program in Ethiopia that links social protection with developing assets and climate resilience within the program (Gilligan *et al*., 2009). This suggests the need for integrated policy design to identify the connections within food systems.

Finally, we need flexible governance in uncertain times. Increasing shocks and uncertainties, such as climate change and market volatility, mean food systems are becoming more vulnerable. Static policy settings, which are designed for a stable world, are not suitable. We need responsive and adaptive governance. Adaptive governance in Bangladesh for flood management and early warning systems demonstrates the success of these strategies in enhancing resilience and reducing vulnerability (Saha *et al*., 2016). Adaptive governance hinges on good data collection and feedback mechanisms, so that policy can respond to emerging risks. In this regard, the role of digital technologies and information systems is increasing.

These cross-cutting ideas highlight the fact that food security policy is about managing a complex system, not individual interventions. As a result, we need consistent, effective, politically sensitive, integrated and adaptive policies.

10. Policy Trade-offs

Dilemmas are a natural part of food security policy. These arise because of scarcity, the multiple objectives of policy and the positive and negative effects of policy. Recognizing and managing these trade-offs is essential in designing sound policies.

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One such dilemma is the efficiency-versus-equity trade-off. Policies that prioritize efficiency, such as market liberalization and removal of subsidies, can improve efficiency and fiscal balance. However, they can also adversely affect the poor via food price increases or reduced access to essential inputs. Alternatively, equity-oriented policies, such as universal food subsidy programs, can raise food access for the poor but can also have negative impacts on fiscal budgets and markets. For example, Egypt's food subsidy program has played a vital role in assisting food access, but has also generated significant budgetary pressures, prompting recent reforms efforts (World Bank, 2022). This trade-off calls for policies that fulfil efficiency and social protection objectives.

The second trade-off is between productivity and the environment. Efforts to enhance productivity, using fertilizers, irrigation and land clearing, can raise food production in the short term, but in the long term could reduce natural resource endowments, such as soil fertility, water and lead to greenhouse gas emissions. The notion of a water-energy-food nexus emphasizes the inter-relationship between these. For instance, irrigation increases production but also consumes water and energy. In water-scarce countries such as Jordan, productivity and water efficiency are favored over production. This suggests policies should emphasize sustainable intensification and climate-smart agriculture, as well as a trade-off between increased production and conservation. (FAO, 2016; IPCC, 2022).

The third trade-off relates to short- versus long-term priorities. In response to crises, such as food price shocks or natural disasters, governments tend to focus on short-term responses such as price controls, food assistance or emergency subsidies. These interventions can offer immediate relief but may hinder long-term food security by distorting markets or taking resources away from investments in infrastructure, research and institutions. The Productive Safety Net Program in Ethiopia is an example of trying to address this trade-off by providing short-term food security and building long-term assets and capacity (Gilligan *et al*., 2009). This case study illustrates the need for policy measures to focus on the short term but also increases the resilience of food systems in the long run (Gilligan *et al*., 2009).

A second key trade-off is between policy stability and flexibility. Policy stability is crucial to stimulate investment and ensure predictability for stakeholders. But too much stability can hamper the responsiveness of governments to changing circumstances, especially in the face of climate change and market uncertainty. Flexible policy designs attempt to balance these needs by preserving the design principles of policy while enabling policy design to be responsive to new information and changing conditions. This is achieved through effective monitoring and learning mechanisms.

The last trade-off is between self-sufficiency and globalization. Measures to enhance self-sufficiency can minimize reliance on global markets and improve food security but can also introduce inefficiencies and increase costs. On the other hand, global market integration can enhance efficiency and access but is exposed to risks. Vietnam's participation in world markets has aided agricultural development and exports, while other nations have taken a more measured approach to ensure domestic stability and participation in world markets (Anderson & Martin, 2012).

In sum, these trade-offs underline that designing food security policy is best understood not in terms of achieving one goal but managing multiple, sometimes conflicting goals. Good policy making should be transparent, well-informed and explicitly acknowledge trade-offs. Governments can balance such trade-offs by tailoring policies to institutional and contextual constraints to achieve more effective and inclusive outcomes.

11. Forward-Looking Lessons: Governing Food Systems Under Uncertainty

Developing country food security policy is transitioning to a new era of complexity, uncertainty and interdependence. The cross-case evidence in this chapter suggests that the key to effective policy in the future will not be the selection of specific policy instruments but rather the capacity of governments to develop and implement integrated, adaptable, and resilient food system governance platforms.

Climate variability is one of the key factors of change. The Intergovernmental Panel on Climate Change predicts that extreme climatic events will be more frequent and intense, with impacts on food production,

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supply chains, employment and food security. This suggests that a static policy framework (designed for a stable environment) will become increasingly out of date. Rather, governments will need to shift towards flexible policy approaches that account for uncertainty, allow for continuous learning, and establish swift response mechanisms. Early warning systems, climate information services and contingency funds will be key elements of food security planning.

Meanwhile, the rise of digital technology is revolutionizing food governance. The development of digital identification, mobile payments, remote sensing and big data analytics are allowing for more targeted interventions, monitoring in real time, and institutional alignment. The cases of India's Aadhaar program and Brazil's integrated social registries show how digital technologies can improve the effectiveness of policy response (Muralidharan *et al*., 2016; Lindert *et al*., 2007). But the benefits of digitalization are not guaranteed; they require institutional and data governance arrangements, as well as strategies to address exclusion of vulnerable groups.

Budgetary constraints are also driving policy changes. Debt constraints and other demands on the public purse restrict the ability to implement large and distorting policies, such as universal subsidies. Therefore, there is an increasing focus on efficiency- and targeted interventions such as conditional cash transfers and investments in public goods, like infrastructure, research and extension. This shift needs to be politically managed as changes can encounter opposition.

A further trend is a shift towards nutrition-sensitive and equitable policies. Malnutrition and, in some cases, obesity, raise the need to focus on more than simply energy. Policies should consider the quality of food and diets, food diversity, and health, while also addressing structural inequality based on income, gender and place (HLPE, 2020).

The increasing prominence of the water-energy-food nexus also points to the need for holistic approaches. Water scarcity is an increasingly critical resource in many developing countries. Failure to consider these linkages could lead to unanticipated policy outcomes such as environmental damage or resource depletion. We see the need to balance trade-offs between sectors and policy instruments in countries like Jordan.

Lastly, the growing complexity of food systems requires more inclusive and participatory governance. Decentralization and stakeholder participation, as well as public-private partnerships, can improve responsiveness and innovation, but also require effective coordination to ensure policy consistency.

Overall, these developments suggest a paradigm shift towards more flexible, integrated, efficient, inclusive and data-driven food system governance. The challenge for policy makers is no longer just finding the right policies but building the institutional capacity to manage complex systems in a world of uncertainty.

12. Conclusions

This chapter has drawn on comparative evidence to answer the questions of what works, where, and under what conditions in food system governance. This chapter shows that food security outcomes cannot be attributed to specific policy instruments. Rather, they result from the interplay between policies, institutions, markets, political economy and environmental factors. An important implication is that there is no "one size fits all" approach to food security policy. What works in one setting may not in another, depending on the level of institutional and governance capacity, resource constraints, and socio-economic characteristics. This underscores the importance of context-sensitive and flexible policy development, rather than "one-size-fits-all" approaches.

The chapter also highlights a range of general principles for policy design. Policy coherence is key to the alignment of incentives and avoidance of conflicting policy outcomes. Capacity is a key limiting factor for implementation and impact. The political economy of policymaking affects policy sustainability, and reforms need to be technically and politically feasible. Multifaceted policies that link production, market, social protection and environmental policies are more effective than single policies. Lastly, adaptive governance is essential for dealing with uncertainties and changing circumstances.

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The chapter also emphasizes the need to balance competing objectives such as efficiency versus equity, productivity versus sustainability, and short- versus long-term food security. These are inevitable in food system governance and must be made in a transparent and evidence-informed manner. The next key challenge for emerging economies is to shift from policy tweaks to system-wide change. This means creating learning and adaptive institutions, establishing data and digital platforms, and facilitating multi-sector and multi-stakeholder cooperation. It also involves a change in approach from considering food security as a sector to seeing it as a system. In the end, the key to sustainable food security will be for governments to manage food systems holistically, and to balance multiple objectives while responding to various challenges.

References

Acemoglu, D., & Robinson, J. A. (2012). *Why nations fail: The origins of power, prosperity, and poverty*. Crown Publishing.

Anderson, K., & Martin, W. (2012). Export restrictions and price insulation during commodity price booms. *American Journal of Agricultural Economics, 94*(2), 422–427. https://doi.org/10.1093/ajae/aar105

Barrett, C. B. (2010). Measuring food insecurity. *Science, 327*(5967), 825–828. https://doi.org/10.1126/science.1182768

Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S., & Herrero, M. (2013). Adapting agriculture to climate change in Kenya: Household strategies and determinants. *Global Environmental Change, 23*(6), 1596–1605. https://doi.org/10.1016/j.gloenvcha.2013.07.006

FAO. (2016). *Climate-smart agriculture sourcebook*. Food and Agriculture Organization. https://openknowledge.fao.org/server/api/core/bitstreams/b21f2087-f398-4718-8461-b92afc82e617/content

FAO. (2021). *The state of food security and nutrition in the world*. Food and Agriculture Organization. https://www.fao.org/interactive/state-of-food-security-nutrition/2021/en/

Gentilini, U. (2014). *Our daily bread: What is the evidence on comparing cash versus food transfers?* (World Bank Policy Research Working Paper No. 6848). World Bank. https://doi.org/10.1596/19981

Gilligan, D. O., Hoddinott, J., & Taffesse, A. S. (2009). The impact of Ethiopia's Productive Safety Net Programme and its linkages. *Journal of Development Studies, 45*(10), 1684–1706. https://doi.org/10.1080/00220380902935907

Gulati, A., & Banerjee, P. (2015). Rationalizing fertilizer subsidy in India: Key issues and policy options. *Economic and Political Weekly, 50*(32), 59–70. https://www.econstor.eu/bitstream/10419/176325/1/icrier-wp-307.pdf

HLPE. (2020). *Food security and nutrition: Building a global narrative towards 2030*. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome. https://openknowledge.fao.org/server/api/core/bitstreams/8357b6eb-8010-4254-814a-1493faaf4a93/content

IPCC. (2022). *Climate change 2022: Impacts, adaptation, and vulnerability*. Intergovernmental Panel on Climate Change, Cambridge University Press.

Lindert, K., Linder, A., Hobbs, J., & de la Brière, B. (2007). *The nuts and bolts of Brazil's Bolsa Família program: Implementing conditional cash transfers in a decentralized context*. World Bank. https://documents1.worldbank.org/curated/en/972261468231296002/pdf/398530SP1709.pdf

Muralidharan, K., Niehaus, P., & Sukhtankar, S. (2016). Building state capacity: Evidence from biometric smartcards in India. *American Economic Review, 106*(10), 2895–2929. https://doi.org/10.1257/aer.20141346

North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge University Press. https://doi.org/10.1017/CBO9780511808678

Pinstrup-Andersen, P. (2013). Food security: Definition and measurement. *Food Security, 5*(5), 655–661. https://doi.org/10.1007/s12571-013-0291-6

Saha, S. K., Saha, S., & Laskar, P. S. (2016). Food security status in Bangladesh: An analytical overview. *Global Journal of Human-Social Science, 16*(2), 1–8. https://www.researchgate.net/profile/Subrata-Saha-20/publication/392669682_Food_Security_Status_in_Bangladesh_An_Analytical_Overview_Food_Security_Status_in_Bangladesh_An_Analytical_Overview/links/684d13dc24267473b776e6b2/Food-Security-Status-in-Bangladesh-An-Analytical-Overview-Food-Security-Status-in-Bangladesh-An-Analytical-Overview.pdf

Sen, A. (1983). *Poverty and famines: An essay on entitlement and deprivation*. Clarendon Press. https://doi.org/10.1093/0198284632.001.0001

World Bank. (2016). *Indonesia's energy subsidy reform: Lessons learned*. https://doi.org/10.1596/41617

World Bank. (2018). *The state of social safety nets 2018*. https://documents1.worldbank.org/curated/en/427871521040513398/pdf/124300-PUB-PUBLIC.pdf

World Bank. (2019). *Future of food: Harnessing digital technologies to improve food system outcomes*. https://documents1.worldbank.org/curated/en/941601554962010560/pdf/Future-of-Food-Harnessing-Digital-Technologies-to-Improve-Food-System-Outcomes.pdf

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World Bank. (2022). *Food security update*. https://thedocs.worldbank.org/en/doc/b5de315c82b1a3bb32bf30057aad9b74-0320012022/original/Food-Security-Update-LXVIII-Aug-11-2022.pdf

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CHAPTER 16

Adaptive and Evidence-based Policymaking

Adan Noor[1,*] & Iqra Alam[1]
[1]National Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan
Corresponding authors' email: adankaleem510@gmail.com

Abstract

The escalating complexities of global agrifood systems, exacerbated by climate change, demographic shifts, and geopolitical instability, demand a critical departure from static, reactive public policy paradigms. This chapter explores the imperative transition toward adaptive and evidence-based policymaking in developing economies, advocating for robust data driven governance, systematic policy experimentation, and the institutionalization of deep feedback loops. By synthesizing empirical research, theoretical models, and diverse regional case studies, the analysis elucidates how continuous learning mechanisms enhance policy durability amidst sociopolitical and environmental volatility. The chapter critically reviews foundational frameworks, specifically the International Food Policy Research Institute's (IFPRI) Kaleidoscope Model of policy change and Swanson and Bhadwal's principles for adaptive policymaking. Methodologically, it evaluates the integration of Randomized Controlled Trials (RCTs) and digital public infrastructures in shaping and scaling agricultural interventions. Through detailed empirical analyses including the Kissan Card Subsidy Program in Pakistan's Punjab province, the institutionalization and subsequent dismantling of the National Council for Food and Nutritional Security (CONSEA) in Brazil, the political economy of policy experimentation in China, and the data-driven initiatives of Ethiopia's Agricultural Transformation Agency (ATA) the chapter identifies the precise mechanisms that enable successful policy scaling, resilience, and double loop learning. Ultimately, the findings emphasize that autonomous learning institutions, broad stakeholder consensus, and transparent science-policy interfaces are indispensable for developing durable, equitable, and sustainable food security frameworks in the Anthropocene.

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1. Introduction

1.1. The Anthropocene and the Crisis of Global Food Security

Global food insecurity has unequivocally emerged as one of the most pressing and intractable crises of the twenty-first century, currently affecting an estimated 691 to 783 million people worldwide (Iannotti *et al*., 2024). This escalating vulnerability is disproportionately concentrated across developing economies in Africa, Asia, and Latin America, where structural poverty, protracted armed conflicts, and the accelerating, non-linear impacts of climate change converge to destabilize agricultural livelihoods and disrupt food supply chains (Iannotti *et al*., 2024). The traditional paradigms of agricultural administration are often characterized by rigid, top-down directives, highly centralized bureaucracies, and static five-year planning cycles have proven increasingly inadequate in navigating the compounding and cascading shocks of extreme weather events, global pandemics, and shifting macroeconomic pressures. Consequently, the global development community is recognizing that ensuring long-term food availability, affordability, and nutritional quality requires a fundamental paradigm shift from prescriptive government mandates to dynamic, adaptive governance frameworks (Folke *et al*., 2005).

In contemporary agrifood systems, the profound interdependencies between human socio-economic activity and ecological constraints dictate that isolated policy interventions inevitably generate profound, and often unintended, systemic ripple effects. For instance, agricultural policies in many developing nations have historically prioritized the production and subsidization of staple cereals (such as wheat, maize, and rice) to

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achieve baseline caloric sufficiency. While successful in mitigating acute famine, these policies inadvertently stifled agricultural diversification, degraded soil health through chemical intensification, and marginalized smallholder and female food producers who cultivate indigenous, nutrient-dense crops (Iannotti *et al*., 2024). As nations attempt to pivot from merely maximizing caloric output to fostering holistic, sustainable, and nutrition-sensitive food systems, the underlying policy architectures must become exceptionally agile. Modern policymakers are tasked with continuously negotiating the "triple challenge" of ensuring food and nutritional security, supporting equitable rural livelihoods, and maintaining environmental sustainability (Organisation for Economic Co-operation and Development, 2020). This complex, multifaceted mandate necessitates continuous learning, rapid institutional course correction, and the rigorous application of scientific evidence to mitigate risks and capitalize on emerging agricultural technologies. To truly address the scale of this crisis, global institutions must rethink how food security paradigms interact with ecological boundaries, shifting the focus toward decentralized systems that prioritize resilience and equity over mere aggregate volume.

1.2. The Paradigm Shift: From Static Administration to Adaptive Governance

The Organisation for Economic Co-operation and Development (OECD) defines evidence-informed policymaking as a systematic process whereby multiple sources of information including real-time data, official statistics, and rigorous impact evaluations are deliberately consulted before planning, implementing, or altering public policies and programs (OECD, 2020). While the medical and public health fields have long embraced evidence-based protocols through clinical trials, the deep integration of these principles into agricultural and food security policy in developing economies is a relatively recent phenomenon (Rocha & Harris, 2019). This ongoing shift is driven by the stark realization that an effective food security policy cannot rely solely on historical precedent, received wisdom, or political ideology; it must be continuously tested, evaluated, and refined against empirical realities on the ground.

Furthermore, the concept of "adaptive policymaking" has emerged specifically to address the profound uncertainties inherent in climate-stressed agricultural systems. Under this paradigm, policies are increasingly defined not merely as static, immutable rules, but as broad statements of purpose operationalized through flexible instruments that anticipate and respond to changing conditions (Swanson & Bhadwal, 2009). Adaptive policies are structurally designed to perform well under a wide range of anticipated future scenarios while retaining built-in triggers for immediate adjustment when contextual factors shift significantly (Swanson & Bhadwal, 2009). This adaptability relies heavily on the presence of durable "learning institutions" specialized entities, universities, and multi-stakeholder councils that manage knowledge, track longitudinal data, and foster an institutional memory that effectively outlasts short-term political and electoral cycles. By integrating these feedback mechanisms into the legislative foundation, governments can establish a more robust buffer against both anticipated climate volatility and unanticipated socio-economic crises.

1.3. Objectives and Chapter Organization

The primary objective of this chapter is to rigorously analyze the structural mechanisms through which adaptive and evidence-based policymaking enhances food security and agrifood system resilience in developing economies. It seeks to unpack the theoretical and practical underpinnings of policy durability, demonstrating how data-driven governance, rigorous policy experimentation, and structured feedback loops transform rigid bureaucratic systems into responsive, learning-oriented networks.

This chapter is structured to systematically bridge theory and practice. Section 2 provides a critical literature review of the agrifood systems framework, contrasting traditional public administration with adaptive governance, and exploring the digital turn toward data-driven governance. Section 3 outlines the conceptual and theoretical frameworks guiding the analysis, specifically focusing on the IFPRI Kaleidoscope Model of policy change, Swanson and Bhadwal's adaptive policy principles, and the organizational theory of single, double, and triple-loop learning. Section 4 examines the methodology of evidence generation, critically evaluating the role of Randomized Controlled Trials (RCTs) and the necessity of digital data infrastructures. Section 5 presents a detailed discussion of empirical results through four distinct national case studies:

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Pakistan, Brazil, China, and Ethiopia. Section 6 translates these findings into actionable policy implications for governments and development practitioners. Finally, Section 7 offers a comprehensive conclusion synthesizing the chapter's contributions to the broader discourse on sustainable development and food sovereignty.

2. Literature Review: Navigating the Agrifood Policy Landscape

2.1. The Agrifood Systems Framework and the Evidence Gap

The academic discourse surrounding food security policy has evolved significantly over the past three decades. Historically, agricultural economics and development policy prioritized interventions aimed at maximizing the aggregate supply of staple crops through input subsidies and technological transfers, heavily mirroring the productivist ethos of the Green Revolution. However, since the 1990s, interdisciplinary scholarships have advocated for a more holistic, systems-level understanding of food security that transcends mere agricultural production. The contemporary agrifood systems framework encompasses five distinct but interconnected elements: food availability, food affordability, nutritional quality, promotion (social behavior change and marketing), and long-term sustainability (Iannotti *et al*., 2024).

A critical review of the existing literature reveals significant asymmetries and gaps in how these five elements are governed and researched. While there is a robust and mature evidence base supporting the efficacy of affordability interventions such as conditional and unconditional cash transfers, as well as school feeding programs that deliver multiple educational and nutritional benefits interventions targeting the newer elements of the food environment remain drastically under-researched (Iannotti *et al*., 2024). For instance, evidence regarding the long-term impacts of sustainability practices (such as agroecological transitions and biodiversity conservation) or the regulation of food promotion (such as restricting the marketing of ultra-processed foods to children) is currently minimal in developing contexts (Iannotti *et al*., 2024). Furthermore, systematic reviews indicate that existing Food-Based Dietary Guidelines (FBDGs) in many developing nations frequently fail to reflect the latest epidemiological evidence or the actual realities of the local food supply, highlighting a critical breakdown at the science-policy interface (Iannotti *et al*., 2024). To bridge this gap, contemporary literature overwhelmingly advocates for multisectoral approaches that scale evidence-based interventions across all domains of the food environment, emphasizing the need for translational implementation science to convert raw agricultural data into actionable, holistic governance (Iannotti *et al*., 2024). Bridging this gap also entails actively rethinking how scientific guidelines are communicated to marginalized populations to ensure high adoption rates and long-term behavioral transformation.

2.2. Traditional Public Administration vs. Adaptive Governance

The theoretical transition from traditional government administration to adaptive governance represents a major focal point in recent environmental, public policy, and agricultural literature. Traditional public administration typically relies on hierarchical command-and-control structures, linear planning processes, compartmentalized ministries (e.g., separating agriculture, water, and health), and rigid regulatory enforcement. While highly effective in stable, predictable environments, this model routinely falters when confronted with the "wicked problems" of climate change and systemic food insecurity, where linear causal models are elusive and policy environments are highly volatile.

Adaptive Governance (AG) has emerged as an alternative paradigm specifically designed to manage complex socio-ecological systems (SES) characterized by rapid, unpredictable change and high degrees of uncertainty (Chaffin *et al*., 2014; Folke *et al*., 2005). Grounded deeply in ecological resilience theory, adaptive governance integrates science, policy, and decision-making to manage *for* change rather than attempting to insulate systems against it (Folke *et al*., 2005). Implementing adaptive governance requires a structural shift from hierarchical dictation to horizontal coordination, enticement, and broad multi-stakeholder participation (Jordan & Moore, 2023). This decentralized, networked approach facilitates the rapid processing of local, indigenous, and scientific knowledge, enabling institutions to detect early warning signals of crop failures or resource constraints, and empowering them to initiate immediate, context-specific responses before localized shocks escalate into national crises. Consequently, AG shifts the focus away from

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singular efficiency and toward deliberate, calculated redundancy that protects systems from catastrophic failure.

2.3. The Digital Turn: Data-Driven Governance and Its Discontents

The advent of digital technologies has revolutionized the capacity for evidence-based policymaking, giving rise to the paradigm of "data-driven governance." In the context of global food security, data-driven governance leverages big data analytics, the Internet of Things (IoT), artificial intelligence (AI), and high-resolution satellite remote sensing to replace intuition-based decision-making with empirical precision (Kamilaris *et al*., 2017). In developing economies, digital platforms are increasingly utilized to provide smallholder farmers with personalized agronomic guidance, early weather alerts, and real-time market pricing, which studies indicate can lower resource consumption and boost crop yields by 10% to 30% (Kamilaris *et al*., 2017). Beyond farm-level productivity, national monitoring systems utilize spatial data and algorithmic modeling to target social protection mechanisms, optimize the distribution of subsidized inputs, and monitor environmental compliance with unprecedented granularity.

However, critical literature also strongly cautions against the uncritical adoption of data-driven models, warning against techno-solutionism. Scholars warn of "algorithmic bias" which can manifest as allocative harm (withholding resources or credit based on prejudiced, automated assumptions) or representational harm (reinforcing the subordination of marginalized groups within data sets) (UNESCAP, 2019). The literature emphasizes that data infrastructures must be coupled with inclusive, participatory governance to prevent the exacerbation of existing rural inequalities, particularly the digital divide between large agribusinesses and resource-poor smallholders (UNESCAP, 2019). Furthermore, a lack of integration between computational models and sociological realities can lead to poorly structured feedback loops, where automated policies optimize for isolated, easily measurable metrics (e.g., aggregate yield) at the severe expense of broader systemic resilience and social equity. Ensuring that algorithms are audited for fairness and that human-in-the-loop oversight remains active is critical for maintaining public trust in digital governance systems.

2.4. Institutional Memory and Policy Durability

A central concern within the literature on policy reform is the concept of "policy durability." Policy durability refers to the capacity of a regulatory framework or public program to withstand political transitions, economic shocks, administrative turnover, and shifting electoral landscapes while maintaining its core objectives and operational efficacy (Hochman & Zilberman, 2023). Research on environmental and agricultural regulations highlights a dialectical relationship between durability and flexibility; a policy must be rigid enough to prevent regulatory capture by vested commercial interests, yet flexible enough to undergo iterative improvement based on new scientific evidence (Jordan & Moore, 2023). Durable policies must anchor sustainable forms of production without becoming obsolete rigidities that block deeper structural transformations over time (Folke *et al*., 2005).

The durability of food security interventions is intimately linked to the strength of "learning institutions". Higher education facilities, agricultural research boards, independent statistical agencies, and institutionalized civil society councils serve as vital repositories of technical expertise and institutional memory (Pahl-Wostl, 2009). When governments actively partner with these learning institutions to co-produce knowledge and manage data, they create structural anchors that buffer policies against the volatility of election cycles. The literature consistently demonstrates that policies crafted through broad, multi-stakeholder dialogues incorporating both Western scientific data and local indigenous knowledge systems secure greater community buy-in, thereby reducing the likelihood of abrupt policy reversals and ensuring long-term, sustainable systemic transformation (Leão & Maluf, 2012).

3. Conceptual and Theoretical Frameworks

To systematically analyze how empirical evidence and continuous learning mechanisms shape food security outcomes, this chapter relies on three intersecting theoretical frameworks: the Kaleidoscope Model of policy change, Swanson and Bhadwal's Adaptive Policy Principles, and the organizational taxonomy of learning

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loops. Together, these frameworks provide a comprehensive lens for evaluating how policies are born, how they survive uncertainty, and how they evolve.

3.1. The IFPRI Kaleidoscope Model of Policy Change

Developed by the International Food Policy Research Institute (IFPRI) with support from the United States Agency for International Development (USAID), the Kaleidoscope Model (KM) provides a robust, applied analytical framework for understanding the complex drivers of policy change within the agriculture and nutrition sectors of developing economies (Resnick *et al*., 2018). Recognizing that policymaking is rarely a linear, rational process, the model derives its name from the idea that, much like a kaleidoscope, shifting the analytical focus to different stages of the policy cycle reveals a constantly changing constellation of critical variables, veto players, and actor networks.

The KM maps the trajectory of policy reform across five distinct stages agenda setting, design, adoption, implementation, and evaluation and reform identifying 16 inductively derived, testable hypotheses regarding the proximate causes of policy change (Resnick *et al*., 2018). These primary causal variables are continuously shaped by a broader outer circle of contextual conditions, including macroeconomic shocks, changing demographics, and environmental crises (Resnick *et al*., 2018).

Table 16.1 illustrates the structural components of the Kaleidoscope Model, synthesizing the key variables and hypotheses at each stage of the policy continuum (Resnick *et al*., 2018).

Table 16.1: The Kaleidoscope Model of Policy Change

Policy Stage	Key Variables / Hypotheses Driving Change	Core Mechanism of Action
1. Agenda Setting	1. Relevant Problem 2. Focusing Events 3. Powerful Advocates	Issues gain governmental traction only when recognized as urgent (often triggered by focusing events like famines or market crashes) and championed by influential domestic or international actors.
2. Policy Design	4. Knowledge & Research 5. Norms, Biases, & Ideology 6. Cost-Benefit Calculations	Potential solutions are formulated based on available empirical evidence, heavily filtered through the ideological lens and cognitive biases of decision-makers, and weighed against political and financial feasibility.
3. Adoption	7. Proponents vs. Opponents 8. Government Veto Players 9. Propitious Timing	Formal legislative enactment depends on overcoming opposition from vested interests, navigating institutional veto points (e.g., ministries of finance), and acting during politically favorable windows.
4. Implementation	10. Requisite Budget 11. Institutional Capacity 12. Implementing Veto Players 13. Policy Champions	Successful execution requires sustained budgetary funding, bureaucratic administrative competence, and the continued, active commitment of champions to overcome bureaucratic inertia at the local level.
5. Evaluation & Reform	14. Changing Information 15. Changing Material Conditions 16. Institutional Shifts	Policies are revised, expanded, or terminated based on new monitoring data, shifts in underlying ecological/economic realities, or significant changes in government architecture.

By utilizing KM, researchers and policymakers can pinpoint exactly where an agricultural intervention is succeeding or failing. For instance, a policy might possess strong empirical backing and ideal cost-benefit ratios during the Design phase, but fail entirely during Implementation due to inadequate institutional capacity, lack of sustained funding, or the active resistance of local-level veto players. Incorporating these variables enables stakeholders to map political economy pathways carefully, moving away from purely technocratic views of policy failure.

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3.2. Swanson and Bhadwal's Principles of Adaptive Policymaking

While the Kaleidoscope Model outlines the political mechanics of how policies change, Swanson and Bhadwal's framework prescribes how policies *should be designed* from the outset to manage profound uncertainty. Based on extensive, multi-year empirical studies of water and agriculture policies in regions like Canada and India, the framework posits that static policies actively hinder a society's ability to cope with climate volatility and economic shocks (Swanson & Bhadwal, 2009).

Swanson and Bhadwal propose seven core principles for creating adaptive policies that remain robust in an unpredictable world (Swanson & Bhadwal, 2009):

1. **Integrated and Forward-Looking Analysis:** Utilizing advanced scenario planning, predictive modelling, and foresight exercises to anticipate a broad spectrum of potential future economic, demographic, and climatic conditions rather than planning for a single expected outcome.
2. **Multi-Stakeholder Deliberation:** Engaging diverse groups including marginalized smallholder farmers, agribusinesses, indigenous communities, and civil society to ensure the policy accounts for diverse practical realities and secures long-term sociopolitical consensus.
3. **Automatic Policy Adjustment:** Establishing predefined performance indicators and thresholds that trigger automatic recalibrations in policy parameters. For example, automatically scaling up emergency social safety nets or crop insurance payouts when satellite data indicates severe drought conditions, bypassing lengthy legislative debates (Swanson & Bhadwal, 2009).
4. **Enabling Self-Organization and Social Networking:** Empowering local communities, cooperatives, and farmer networks to adapt autonomously within a broad, permissive regulatory framework, fostering grassroots resilience (Swanson & Bhadwal, 2009).
5. **Decentralization of Decision-Making:** Pushing administrative authority to the lowest effective and capable administrative level (e.g., municipal or district governments) to ensure interventions are locally appropriate and highly responsive to micro-climates (Swanson & Bhadwal, 2009).
6. **Promoting Variation:** Treating diverse regional policies as a portfolio of experiments, allowing the overall system to learn which approaches yield the best results under varying conditions, thereby reducing systemic risk (Swanson & Bhadwal, 2009).
7. **Formal Policy Review and Continuous Learning:** Embedding mandatory, rigorous, and independent evaluation cycles into the legislation itself to capture lessons learned and systematically correct systemic failures, even when the policy appears to be functioning well (Swanson & Bhadwal, 2009).

3.3. Organizational Learning: Single, Double, and Triple-Loop Feedback Mechanisms

The ultimate efficacy of both data-driven governance and adaptive frameworks rests on the quality of their "feedback loops" the cyclical processes where the output of an agricultural system (e.g., crop yields, soil degradation, poverty rates) is fed back into the governance system to inform future inputs, budgets, and policy decisions (Pahl-Wostl, 2009).

Public administration and organizational theory categorize these feedback mechanisms into three distinct levels of learning depth:

- **Single-Loop Learning ("Are we doing things, right?"):** This involves routine, corrective adjustments to improve the efficiency of an existing policy without questioning its fundamental objectives or underlying logic. For example, digitizing a fertilizer subsidy program to reduce bureaucratic delays, combat corruption, and speed up delivery constitutes single-loop learning. The goal remains the same; the execution simply becomes more efficient.

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- **Double-Loop Learning ("Are we doing the right things?"):** This deeper, more transformative level of learning occurs when performance data reveals that the existing policy framework is fundamentally flawed, prompting a critical reassessment of underlying goals and assumptions. If empirical evidence shows that a fertilizer subsidy is severely degrading long-term soil health and failing to improve nutritional outcomes, shifting the entire policy focus from maximizing cereal yields to subsidizing agroecological practices and dietary diversity represents double-loop learning. This depth of learning actively changes the primary strategic aims of a governance framework.

- **Triple-Loop Learning ("Are we learning right?"):** The deepest level involves transforming the institutional architecture and epistemological foundations of learning itself. This might involve a government realizing its data collection methods are inherently biased against women farmers, leading to the establishment of new, participatory data-sharing consortiums between universities, farmers, and the state to continuously rethink how evidence is gathered, validated, and utilized (Pahl-Wostl, 2009).

Policies that achieve true durability are those institutionalized within environments capable of sustained double and triple-loop learning, ensuring they evolve intelligently rather than rigidly persisting in the face of continuous disruption. The transition from merely optimizing bad systems (single loop) to redefining structural purposes entirely (double/triple loop) remains the hardest challenge in public administration today.

4. Methodology of Evidence Generation in Policy Environments

To practice authentic evidence-based policymaking, governments, NGOs, and multilateral institutions require rigorous methodologies to ascertain the true causal impacts of agricultural interventions. This section details the primary methods used to generate actionable data, their inherent limitations in the context of developing economies, and the technological infrastructure required to support them.

4.1. The Role and Limits of Randomized Controlled Trials (RCTs)

In the aggressive push for evidence-based policymaking over the past two decades, the application of Randomized Controlled Trials (RCTs) has become a gold standard within development economics and agricultural policy (Weigel *et al*., 2021). Pioneered in the social sciences by organizations such as the Abdul Latif Jameel Poverty Action Lab (J-PAL) and the Agricultural Technology Adoption Initiative (ATAI), RCTs involve randomly assigning individuals, villages, or regional markets to a "treatment" group (which receives the intervention) or a "control" group (which does not). Because the assignment is strictly random, any statistically significant difference in outcomes between the two groups can be causally attributed to the policy intervention, eliminating selection bias. The growing volume of RCTs in this area is substantial, expanding ten-fold to over 1000 studies annually across the globe, documented systematically by the American Economic Association (AEA) RCT Registry (David *et al*., 2024).

RCTs have been instrumental in isolating the specific variables that drive agricultural technology adoption among smallholder farmers. For example, extensive field experiments and meta-analyses have empirically demonstrated that providing information or credit alone is rarely sufficient to boost farmer profits or technology uptake. Instead, evidence shows that bundling credit with weather-index insurance and tailored digital extension services significantly increases the adoption of climate-resilient seeds. Furthermore, RCTs allow policymakers to test precise variations of a policy such as comparing the effectiveness of flexible versus inflexible in-kind agricultural grants, or different behavioral "nudges" for reducing food waste before committing to a costly national rollout (McIntosh, 2024). By embracing policy experimentation, governments move beyond passive observation. Experimentation puts the manipulability of a policy to the test, uncovering behavioral nuances, unexpected cultural barriers, and implementation frictions that ex-post observational analyses frequently miss (Wang & Yang, 2021).

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4.2. Capturing General Equilibrium Effects in Scaling Interventions

Despite their unparalleled methodological rigor in establishing localized causality, RCTs present specific, highly consequential challenges when applied to macroeconomic food security policy. Small-scale experiments are notoriously resource-intensive, time-consuming, and often raise profound ethical concerns regarding the deliberate exclusion of control groups from potentially life-saving interventions in complex humanitarian emergencies.

More critically, RCTs frequently struggle to capture General Equilibrium (GE) effects the systemic, economy-wide economic shifts that occur when a program is scaled up from a pilot village to an entire region or nation. For instance, a well-designed RCT evaluating a modern seed and fertilizer subsidy might show a dramatic, highly significant increase in crop yields for the treated farmers. However, if that exact policy is rolled out nationally, the sudden, massive surge in aggregate crop production could drastically depress local market prices. This GE price effect could potentially leave farmers with lower net incomes despite their higher yields, completely undermining the policy's poverty-reduction goals. Simultaneously, a national rollout might increase the local demand for agricultural labor, driving up rural wages and altering the broader economy in ways the initial RCT could not detect.

To address these inherent limitations, modern evidence-based policymaking increasingly relies on hybrid, multifaceted methodologies. Researchers and state planners are pioneering approaches that combine the localized causal identification of experimental data with spatial and computable general equilibrium models. This synthesis allows governments to accurately forecast the distributional and systemic impacts of scaling up interventions, ensuring that policies remain effective outside the vacuum of a controlled experiment (Bergquist *et al*., 2022).

4.3. Digital Public Infrastructure (DPI) and Real-Time Data Architectures

While RCTs provide discrete, episodic evidence of what works, adaptive governance requires a continuous, unbroken flow of high-quality data to fuel automatic policy adjustments. Consequently, developing economies are heavily investing in digital infrastructures designed to capture systemic performance in real-time. The deployment of the Internet of Things (IoT) in agriculture such as soil moisture sensors, connected weather stations, and automated guided vehicles (AGVs) allows for the generation of massive, granular datasets that map resource utilization at the micro-level (Iannotti *et al*., 2024; Kamilaris *et al*., 2017). At the macro-level, Geographic Information Systems (GIS) and satellite remote sensing are routinely utilized to monitor crop health, predict localized drought conditions, map salinity intrusion, and verify environmental compliance (Badmus & Olamide, 2025).

Establishing a functional data-driven governance framework requires three foundational pillars of Digital Public Infrastructure (DPI):

1. **Interoperable Data Registries:** Moving away from siloed, paper-based bureaucratic data toward integrated national digital registries. This involves linking a national farmer identity database with real-time market pricing, mobile money payment systems (similar to Rwanda's Mojaloop integration for financial inclusion), and meteorological data (Digital Public Goods Alliance, 2023). Interoperability prevents single-point failures and ensures comprehensive analytics across previously disconnected ministries.
2. **Predictive Analytics and Decision-Support Tools:** Utilizing machine learning algorithms and multi-criteria decision analysis (MCDA) to process vast data streams, enabling proactive interventions such as dispatching early warnings or pre-positioning food aid rather than relying on reactive disaster relief (Badmus & Olamide, 2025).
3. **Institutional Capacity and Literacy:** Investing heavily in the digital literacy of civil servants, agricultural extension workers, and farmers to ensure that data insights are correctly interpreted and utilized to refine policy feedback loops without succumbing to algorithmic bias (UNESCAP,

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2019). Digital transformation must be coupled with organizational culture change to realize actual productivity gains.

5. Results and Discussion: Empirical Case Studies in Adaptive Policymaking

The theoretical imperatives of adaptive and evidence-based policymaking are best understood through their application in diverse socio-economic contexts. The following four case studies illustrate how developing economies navigate the complexities of data-driven governance, policy experimentation, and the institutionalization of learning to enhance food security.

5.1. Pakistan: Digitizing Agricultural Subsidies through the Punjab Kissan Card

Agriculture is the foundational backbone of Pakistan's economy, contributing approximately 19.2% to the national GDP and employing nearly 40% of the labor force (GoP, 2024). The province of Punjab, universally recognized as the nation's breadbasket, has historically struggled with stagnant agricultural growth. This stagnation was largely driven by outdated, blanket subsidy regimes established in the 1960s that encouraged the overproduction of water-intensive staple cereals (to achieve basic food security) at the severe expense of high-value horticulture, livestock development, and ecological sustainability (Government of Punjab, 2018).

To modernize the sector and break this path dependency, the Government of Punjab initiated the Agriculture Policy 2018, pivoting aggressively toward data-driven governance, market expansion, and direct-to-farmer support mechanisms (Government of Punjab, 2018). A cornerstone of this reform is the Kissan Card Subsidy Program (KCSP), an intervention designed to digitize the distribution of agricultural subsidies, streamline e-credit access, and eliminate corrupt intermediaries and commission agents (Yifei *et al*., 2026).

A rigorous impact evaluation of the KCSP, utilizing primary survey data from 440 farming households across highly vulnerable districts in Southern Punjab (Lodhran, Rahim Yar Khan, Layyah, and Muzaffargarh), demonstrated the profound efficacy of targeted, digitized interventions. Employing a double robust econometric approach specifically Propensity Score Matching (PSM) and Inverse Probability Weighted Regression Adjustment (IPWRA) to strictly control for selection bias the analysis revealed significant, causal improvements in household food security (Yifei *et al*., 2026).

Table 16.2 summarizes the statistical impact of the KCSP on key food security metrics, notably the Food Consumption Score (FCS) and the Household Food Insecurity Access Scale (HFIAS).

Table 16.2: Impact of the Kissan Card Subsidy Program (KCSP) on Food Security Metrics in Punjab, Pakistan

Variable	Description	Mean	Std. Dev.	T-test (Difference)
KCSP Participation	1 = if farmers participate in government subsidy program (Kissan Card), 0 = otherwise	0.404	0.483	N/A
FCS	Household Food Consumption Score (FCS)	37.824	16.069	-37.703***
HFIAS	Household Food Insecurity Access Scale (HFIAS) score	2.842	1.011	40.718
Age	Number of years	44.013	14.975	-0.339

Note: *** indicates high statistical significance. A higher FCS indicates improved dietary diversity, while a lower HFIAS indicates reduced vulnerability to food insecurity

The empirical data unequivocally indicates that households participating in the KCSP exhibited heightened dietary diversity (a higher FCS) and a statistically significant reduction in food insecurity (Yifei *et al*., 2026). Crucially, the evaluation highlighted the mediating role of digital inclusion; the program's positive impact on income and food security was highly correlated with a farmer's prior access to ICT tools and digital extension assistance (Yifei *et al*., 2026).

However, the program also revealed critical constraints characteristic of single-loop learning. While the KCSP effectively alleviated liquidity constraints for land-owning farmers, structural barriers in the digital registry systematically excluded tenant farmers who lacked formal land titles (Yifei *et al*., 2026). Furthermore, while the subsidies increased overall yields, they inadvertently incentivized the adoption of

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input-intensive, stress-tolerant crop varieties (STVs) while simultaneously reducing the uptake of ecologically sustainable practices like integrated pest management (IPM) and organic manuring (Yifei *et al*., 2026).

To facilitate the double-loop learning necessary to correct these distortions, the Punjab government leverages institutions like the Punjab Agricultural Research Board (PARB). Established to coordinate research and manage competitive grants, PARB serves as the vital institutional memory required to evaluate such empirical findings, pushing the policy agenda toward complementary nutrition interventions, expanded digital literacy, and conditional subsidies that mandate ecological sustainability (Government of Punjab, 2018). Concurrently, digital initiatives like the Groundwater Management Information System (GMIS) are a collaborative, web-based tool that aggregates groundwater-related data into a single platform to support monitoring and planning, developed using a CGIAR Scaling Readiness approach (Stifel, 2024). The collaborative framework used to build GMIS illustrates that technical conditions must be deeply intertwined with social and institutional mandates for these platforms to genuinely aid local communities.

5.2. Brazil: Policy Durability and the Institutionalization of CONSEA

Brazil's historical experience provides a profound and sobering lesson in the political economy of food security, highlighting the vital role of institutionalizing multi-stakeholder participation to achieve true policy durability. In 2003, the Brazilian government launched the *Fome Zero* (Zero Hunger) initiative, a massive, integrated social strategy that fundamentally shifted the national approach from fragmented agricultural supply management to a comprehensive, human rights-based framework for food and nutritional security.

A critical element in the architecture of Brazil's success was the re-establishment and empowerment of the National Council for Food and Nutritional Security (CONSEA) (Chmielewska & Souza, 2011). Acting as the primary science-policy interface and apex advisory body, CONSEA was uniquely structured to prevent bureaucratic echo chambers: two-thirds of its members were representatives from diverse civil society organizations (including indigenous groups, family farmers, and nutritionists), while one-third were government officials. This structure deeply embedded the principles of adaptive governance by democratizing the policy process. CONSEA facilitated continuous, structured dialogue, allowing local knowledge regarding agroecological farming, regional diets, and the lived experiences of marginalized communities to directly inform federal policy design (Chmielewska & Souza, 2011).

Under this robust, participatory governance model, transformative programs such as the National School Feeding Program (PNAE) and the Food Acquisition Program (PAA) were implemented. These programs generated a virtuous cycle of feedback by mandating that a minimum of 30% of all public-school food purchases be sourced directly from local family farms, thereby simultaneously addressing childhood malnutrition and rural poverty while circumventing massive agribusiness monopolies (Gueneau & Niederle, 2020). Through CONSEA's relentless advocacy and evidence-based lobbying, the right to adequate food was formally inscribed into the Brazilian Constitution in 2010, theoretically cementing the legal durability of the National Policy for Food and Nutritional Security (PNSAN) (Leão & Maluf, 2012).

However, the resilience of these frameworks was severely tested by extreme political shocks. Following administrative changes in 2019, the incoming government immediately abolished CONSEA and began dismantling the public food storage capacities of the National Supply Company (Conab) (Gueneau & Niederle, 2020). The sudden disruption of these key learning and coordination institutions significantly impaired the state's capacity to respond to subsequent crises, such as the COVID-19 pandemic. Without the feedback loops provided by CONSEA, emergency responses faltered, resulting in the rapid and tragic re-emergence of severe food insecurity and hunger among millions of vulnerable populations (Gueneau & Niederle, 2020).

Applying the IFPRI Kaleidoscope Model to the Brazilian context underscores a critical vulnerability: while the *Policy Design* and *Adoption* stages can achieve remarkable consensus and impact, the *Evaluation and Reform* stages remain highly vulnerable to ideological shifts in supreme *Veto Players*. The eventual, hard-fought reinstatement of CONSEA in 2023 highlights that while political discontinuity can severely fracture

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policy implementation, the deep institutional memory, empirical evidence base, and mobilization capacity residing within civil society networks are essential mechanisms for resurrecting and defending durable food policies.

5.3. China: The Political Economy of Policy Experimentation

China presents a compelling, large-scale case study of how policy experimentation is systematically utilized to resolve uncertainty and facilitate evidence-based learning. Since 1980, the Chinese government has engaged in some of the most extensive agricultural and economic policy experimentations in recent history (Wang & Yang, 2021). By actively piloting interventions such as decentralized rural governance models, agricultural tax reforms, and ecological compensation schemes before a nationwide rollout, the state embodies the principles of adaptive, sequential experimentation.

However, empirical evaluations of these experimental frameworks reveal critical nuances that complicate the direct translation of localized data into national policy. Recent comprehensive analyses of China's policy experimentation demonstrate significant political economy challenges that can distort single and double-loop learning mechanisms (Wang & Yang, 2021).

Table 16.3 illustrates the primary characteristics and structural limitations identified within these experimental policy frameworks.

Table 16.3: Characteristics and Limitations of Policy Experimentation in China (Wang & Yang, 2021)

Experimental Characteristic	Empirical Finding	Impact on Policy Learning and Durability
Positive Sample Selection	Approximately 90% of policy experiments are conducted in localities with higher-than-average economic development.	Results in severe selection bias; successful outcomes in affluent regions frequently fail to replicate in poorer, resource-constrained areas.
Resource Allocation Bias	Career-driven local politicians allocate disproportionate administrative and financial resources to ensure the pilot's success.	Creates an artificial 'greenhouse' effect; the high effort level is not sustainable or replicable when the policy is rolled out nationwide.
Interpretation Bias	The central government often interprets localized, highly subsidized successes as universally applicable mandates.	Distorts national policy directives, leading to widespread implementation failures when external validity is assumed without critical adjustment.

Note: Data synthesized from comprehensive assessments of policy experiments conducted over four decades

This case study fundamentally challenges the assumption that localized policy experimentation automatically leads to robust, durable national governance. While the active intervention and manipulation of policy treatments provide deeper engaged learning than passive observation, the political incentives of local officials actively skew the generated evidence (Wang & Yang, 2021). When career advancement is tethered to the success of an agricultural pilot, local authorities over-invest resources, generating an artificial success rate. Consequently, when the central government scales these policies without accounting for this resource bias, the resulting national frameworks often lack durability and fail to achieve their intended food security or economic objectives. This highlights a crucial double-loop learning imperative: for adaptive governance to succeed, the institutional structures evaluating the evidence must rigorously account for the political economy of how that evidence was produced (Wang & Yang, 2021).

5.4. Ethiopia: Catalyzing Transformation through the ATA

Ethiopia provides a compelling, world-class case study on the creation of specialized "learning institutions" designed specifically to catalyze evidence-based policy implementation and overcome bureaucratic inertia. Despite sustaining high macroeconomic growth rates over the past two decades, Ethiopia's agricultural sector which employs over 75% of the population, primarily on small, fragmented, rain-fed plots has historically struggled with low productivity, land degradation, and severe structural bottlenecks.

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Recognizing that traditional ministerial structures lacked the agility, cross-sectoral coordination, and advanced analytical capacity required to rapidly modernize the sector, the Ethiopian government established the Agricultural Transformation Agency (ATA) (subsequently renamed the Agricultural Transformation Institute, ATI). Functioning as a highly strategic, data-driven learning institution, the ATA was mandated to identify systemic constraints, design innovative, evidence-based solutions, and coordinate execution across various ministries and regional governments. By actively partnering with global research entities such as IFPRI to build internal capacity and utilizing robust diagnostic tools, the ATA embedded evidence-based decision-making directly into the state's bureaucratic apparatus.

A rigorous, large-scale evaluation of the ATA's interventions implemented between 2011 and 2016, utilizing high-resolution remote-sensing data combined with extensive household panel surveys, demonstrates the profound impact of scaling data-informed practices. The empirical strategy revealed that the ATA's multifaceted agricultural interventions successfully increased crop yields and significantly improved aggregate food security outcomes across the targeted regions (FAO, 2020). Furthermore, an evaluation by the UN Food and Agriculture Organization (FAO) underscored the broad macroeconomic dividends, observing that these interventions not only bolstered household-level food availability but actively sustained broader GDP growth against potential shocks by catalyzing agro-industry and transportation developments.

Interestingly, the application of causal mediation analysis uncovered critical, highly nuanced heterogeneity in the impact pathways. For the most vulnerable, resource-poor households, the agricultural interventions translated directly into enhanced food security via increased domestic food production and caloric availability. Conversely, for better-endowed, relatively wealthier households, the increased agricultural productivity allowed them to fundamentally adjust their livelihood strategies; they utilized the surplus to pursue higher-income off-farm economic opportunities without sacrificing their household nutrition or food security.

This nuanced, empirically derived understanding of differential, heterogeneous impacts is a hallmark of triple-loop learning. By maintaining a sophisticated, continuous data architecture, the ATA systematically avoids blanket, one-size-fits-all policy prescriptions. Instead, it utilizes targeted analytics to refine its operational strategies, demonstrating that centralized, highly capable, data-driven institutions can effectively bridge the massive gap between high-level agricultural policy aspirations and the complex, highly variable socio-economic realities of rural smallholders.

6. Policy Implications for Developing Economies

The synthesis of theoretical frameworks and empirical evidence presented in this chapter underscores several critical, actionable implications for policymakers, multilateral donors, and development practitioners aiming to fortify food security in developing economies. Transitioning toward adaptive, evidence-based governance requires deliberate, sustained investments in institutional design, technological infrastructure, and inclusive democratic processes.

6.1. Institutionalizing Science-Policy Interfaces (SPIs)

To transition beyond the myopia of short-term political and electoral cycles, governments must structurally embed continuous learning and rigorous evaluation into the policymaking apparatus. Developing economies should establish, fund, and legally protect independent, multidisciplinary bodies such as agricultural research boards (e.g., PARB in Pakistan), transformation agencies (e.g., ATA in Ethiopia), or participatory food policy councils (e.g., CONSEA in Brazil) that serve as permanent Science-Policy Interfaces (SPIs).

These institutions act as the vital custodians of institutional memory, conducting continuous scoping exercises, commissioning independent RCTs, and managing longitudinal evaluations to safeguard policy durability (FAO, 2020; Gueneau & Niederle, 2020). Furthermore, governments should actively partner with higher education institutions and universities. By integrating sustainable food systems research into academic curricula and funding localized pilot programs, the state can leverage universities not only to generate context-specific agricultural data but also to train a vanguard of technologically literate extension

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workers and agile policymakers (Pahl-Wostl, 2009). This creates sustainable intellectual reservoirs immune to the shifting winds of temporary political leadership.

6.2. Fostering Adaptive Sequential Experimentation

Governments and international donors must fundamentally shift their mindset to treat policy implementation not as a finalized endpoint, but as an ongoing, iterative experiment (Wang & Yang, 2021). Scaling agricultural interventions should systematically incorporate phased rollouts and Randomized Controlled Trials (RCTs) to rigorously evaluate effectiveness, behavioral responses, and cost-efficiency before committing to a national deployment.

However, explicitly recognizing the limitations of localized RCTs in capturing macroeconomic distortions and general equilibrium effects, policymakers should adopt "adaptive sequential experimentation" (Bergquist *et al*., 2022). This involves creating regulatory sandboxes or innovation policy labs where novel interventions such as digital subsidies, localized food procurement mandates, or climate-index insurance are carefully piloted in specific ecological zones (OECD, 2025). By combining experimental field data with predictive computable general equilibrium models, authorities can accurately anticipate how an intervention will affect regional commodity prices, labor wages, and environmental thresholds, allowing them to proactively mitigate adverse ripple effects before a full-scale, irreversible launch.

6.3. Mitigating Algorithmic Bias in Data-Driven Governance

The effective, rapid administration of modern agricultural policy is intrinsically linked to the quality and equity of its underlying data infrastructure. Developing nations must invest heavily in the digitalization of rural economies, ensuring that extension services, market intelligence, and subsidy delivery are supported by robust, interoperable Digital Public Infrastructure (DPI) and data registries.

Crucially, however, data-driven governance must be managed ethically and transparently to prevent the exacerbation of rural inequalities. Policymakers must be hyper-vigilant against algorithmic biases that could result in allocative harm, ensuring that historically marginalized populations such as tenant farmers without formal land titles, women producers, or ethnic minorities are not systematically excluded from digital platforms, credit algorithms, or subsidy registries (UNESCAP, 2019). To achieve this, technological deployment must be accompanied by community-based participatory design models, ensuring that data architectures are transparent, highly accountable, and that local farmers have a definitive voice in how their information is collected, utilized, and governed (Leão & Maluf, 2012).

6.4. Designing for Durability Through Multi-Stakeholder Consensus

Finally, the longevity, resilience, and ultimate success of any food security policy depend heavily on the breadth and depth of its political and social foundation. Applying the core principles of adaptive policy, governments should consistently engage in broad, formalized multi-stakeholder deliberations during the earliest phases of policy design (Swanson & Bhadwal, 2009).

Actively including civil society organizations, private agribusinesses, marginalized indigenous producers, and technical experts in the drafting and continuous monitoring process as powerfully demonstrated by the early successes of Brazil's CONSEA ensures that the policy addresses actual ground-level realities and secures widespread sociopolitical legitimacy (Gueneau & Niederle, 2020). When a policy represents a negotiated, deeply rooted consensus rather than a unilateral, top-down mandate, it cultivates a protective, highly mobilized network of advocates. These networks serve as the ultimate guarantor of policy durability, capable of defending the framework and its learning institutions against arbitrary reversal during periods of severe political turbulence or administrative turnover (Chmielewska & Souza, 2011).

7. Conclusion

As developing economies confront an unprecedented era characterized by systemic macroeconomic volatility, demographic shifts, and rapidly escalating climate pressures, the traditional, rigid architectures of agricultural administration are no longer sufficient to guarantee national food security. The transition to

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adaptive and evidence-based policymaking represents a vital, non-negotiable evolutionary step, moving away from ideologically driven, static mandates toward highly dynamic governance systems capable of continuous learning, rapid recalibration, and proactive crisis management.

By deeply grounding policy design in robust empirical methodologies ranging from randomized field experiments to real-time digital monitoring and predictive analytics governments can accurately identify and scale the specific interventions that demonstrate nutritional diversity, enhance rural livelihoods, and protect fragile ecological thresholds. Analytical frameworks such as IFPRI's Kaleidoscope Model and Swanson and Bhadwal's adaptive design principles offer actionable, evidence-backed blueprints for navigating the complex political economy of reform, ensuring that policies are not only successfully adopted but systematically evaluated and iteratively refined.

Ultimately, the durability and success of these frameworks rely absolutely on the cultivation and protection of strong, inclusive learning institutions. When states empower specialized agricultural transformation agencies, leverage the rigorous research capacity of higher education, and legally institutionalize the participation of civil society in the governance process, they create resilient, shock-proof networks. It is only through this deep synthesis of rigorous scientific evidence, decentralized administrative adaptability, and broad, democratic social consensus that developing economies can forge enduring agricultural policies capable of nourishing future generations in an increasingly uncertain world.

References:

Badmus, O., & Olamide, A. L. (2025). Integrated predictive and remote-sensing framework for early warning and regulatory compliance in environmentally sensitive urban zones. *International Journal of Geography and Environmental Management, 11*(12), 212–239. https://doi.org/10.56201/ijgem.vol.11.no12.2025.pg212.239

Bergquist, L., Faber, B., Fally, T., Hoelzlein, M., Miguel, E., & Rodriguez-Clare, A. (2022). *Scaling agricultural policy interventions: Evidence from Uganda*. National Bureau of Economic Research. https://doi.org/10.3386/w30704

Chaffin, B. C., Gosnell, H., & Cosens, B. A. (2014). A decade of adaptive governance scholarship: Synthesis and future directions. *Ecology and Society, 19*(3), 56. http://dx.doi.org/10.5751/ES-06824-190356

Chmielewska, D., & Souza, D. (2011). *The food security policy context in Brazil*. International Policy Centre for Inclusive Growth. https://www.econstor.eu/handle/10419/71772

David, T., Cavanagh, J., & Gault, S. (2024). *Next decade of RCT research: What can we learn from recent innovations in methods?* Abdul Latif Jameel Poverty Action Lab. https://www.povertyactionlab.org/blog/2-16-24/next-decade-rct-research-what-can-we-learn-recent-innovations-methods

Digital Public Goods Alliance. (2023). *Building open digital states: Country case studies on the impact of DPGs for DPI*. https://www.digitalpublicgoods.net/dpgs-for-dpi-building-open-digital-states.pdf

Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources, 30*, 441–473. https://doi.org/10.1146/annurev.energy.30.050504.144511

FAO. (2020). *Ten years of the Ethiopian Agricultural Transformation Agency: An FAO evaluation of the Agency's impact on agricultural growth and poverty reduction*. Food and Agriculture Organization of the United Nations. https://openknowledge.fao.org/server/api/core/bitstreams/86fccfc0-3fbd-4d49-8c0a-276ed3c42e7d/content

Government of Punjab. (2018). *Punjab agriculture policy 2018*. Agriculture Department, Government of Punjab, Pakistan. https://agripunjab.gov.pk/system/files/Punjab%20Agriculture%20Policy.pdf

Gueneau, S., & Niederle, P. (2020). *Brazil: The effect of the dismantling of food security policies amplified by COVID-19*. Public Policies and Rural Development in Latin America. https://www.pp-al.org/en/news/brazil-the-effect-of-the-dismantling-of-food-security-policies-amplified-by-covid19

Hochman, G., & Zilberman, D. (2023). Policy durability: Taxes versus standards. *Choices Magazine*. https://www.choicesmagazine.org/UserFiles/file/cmsarticle_877.pdf

Iannotti, L., Kleban, E., Fracassi, P., Oenema, S., & Lutter, C. (2024). Evidence for policies and practices to address global food insecurity. *Annual Review of Public Health, 45*. https://doi.org/10.1146/annurev-publhealth-060922-041451

Jordan, A. J., & Moore, B. (2023). The durability flexibility dialectic: The evolution of decarbonisation policies in the European Union. *Journal of European Public Policy, 30*(3), 425–444. https://doi.org/10.1080/13501763.2022.2042721

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Kamilaris, A., Kartakoullis, A., & Prenafeta-Boldú, F. X. (2017). A review on the practice of big data analysis in agriculture. *Computers and Electronics in Agriculture, 143*, 23–39. https://doi.org/10.1016/j.compag.2017.09.037

Leao, M., & Maluf, R. S. (2012). *Effective public policies and active citizenship: Brazil's experience of building a food and nutrition security system*. ABRANDH. https://www-cdn.oxfam.org/s3fs-public/file_attachments/rr-brazil-experience-food-nutrition-security-190214-en_1_0.pdf

McIntosh, C. (2024). *Increasing small-scale farmers' access to agricultural markets* (J-PAL Policy Insights). Abdul Latif Jameel Poverty Action Lab. https://www.povertyactionlab.org/policy-insight/increasing-small-scale-farmers-access-agricultural-markets

Islamabad, Pakistan. https://finance.gov.pk/survey/chapter_24/2_agriculture.pdf

OECD. (2020). Building capacity for evidence-informed policy-making: Lessons from country experiences (OECD Public Governance Reviews). OECD Publishing. Organisation for Economic Co-operation and Development. https://www.oecd-ilibrary.org/governance/building-capacity-for-evidence-informed-policy-making_9789264621657-en

OECD. (2025). *OECD Science, Technology and Innovation Outlook 2025: Driving Change in a Shifting Landscape*, OECD Publishing, Paris, https://doi.org/10.1787/5fe57b90-en

Pahl-Wostl, C. (2009). A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change, 19*(3), 354–365. https://doi.org/10.1016/j.gloenvcha.2009.06.001

Resnick, D., Haggblade, S., Babu, S., Hendriks, S. L., & Mather, D. (2018). The Kaleidoscope Model of policy change: Applications to food security policy in Zambia. *World Development, 109*, 101–120. https://doi.org/10.1016/j.worlddev.2018.04.004

Rocha, C., & Harris, J. (2019). Evidence-based policymaking in the food–health nexus. *IDS Bulletin, 50*(2). https://doi.org/10.19088/1968-2019.118

Stifel, E. (2024). *Platform wants to save Pakistan's groundwater*. PreventionWeb. https://www.preventionweb.net/news/platform-wants-save-pakistans-groundwater

Swanson, D. A., & Bhadwal, S. (Eds.). (2009). *Creating adaptive policies: A guide for policy-making in an uncertain world*. IDRC/SAGE Publications.

UNESCAP. (2019). *Realizing data-driven governance*. United Nations Economic and Social Commission for Asia and the Pacific. https://repository.unescap.org/server/api/core/bitstreams/7138d353-f01d-4a9b-81c1-36e008a7181d/content

Wang, S., & Yang, D. (2021). *Policy experimentation in China: The political economy of policy learning*. National Bureau of Economic Research. https://www.nber.org/system/files/working_papers/w29402/w29402.pdf

Weigel, C., Paul, L. A., Ferraro, P. J., & Messer, K. D. (2021). Challenges in recruiting U.S. farmers for policy-relevant economic field experiments. *Applied Economic Perspectives and Policy, 43*(2), 556–572. https://doi.org/10.1002/aepp.13066

Yifei, H., Hassan, F. A., Jabbar, A., Ahmad, W., Beldiman, C. M., Antohi, V. M., & Zlati, M. L. (2026). Farm input subsidies and household food security: Evidence from the Punjab Kissan card program in Pakistan. *Frontiers in Sustainable Food Systems, 10*, Article 1714558. https://doi.org/10.3389/fsufs.2026.1714558

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CHAPTER 17

Digital Tools, Data Systems and AI in Food Security Policy

Syed Muhammad Subtain Abbas[1,*], Sharoon Aftab[1], Tayyab Ali[1], Mannan Aleem[2,3], Shoaib Sarwar[1], Yasir Abbas[1], Naeem Saddique[1] & Muhammad Imran Khan[1]
[1]Department of Irrigation and Drainage, Faculty of Agricultural Engineering and Technology, University of Agriculture Faisalabad, Pakistan
[2] Department of Structures and Environmental Engineering, Faculty of Agricultural Engineering and Technology, University of Agriculture, Faisalabad.
[3]Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences, Yantai, China
Corresponding authors' email: subtainadeem48@gmail.com

Abstract

Digital technologies are rapidly reshaping the way food security is monitored, governed, and addressed across the world. This chapter examines the growing role of remote sensing, artificial intelligence (AI), big data analytics, and predictive modelling in strengthening food security policy and early warning systems. Drawing on recent scholarly literature, institutional reports, and comparative international experiences, it explores how digital tools enhance crop monitoring, climate risk assessment, supply chain management, and evidence-based policymaking. At the same time, the chapter highlights persistent challenges related to data governance, digital inequality, algorithmic transparency, data sovereignty, and the unequal distribution of technological capacity between the Global North and Global South. By integrating sociotechnical systems theory, digital sovereignty, and evidence-to-policy translation frameworks, the chapter argues that technology alone cannot solve food insecurity without strong institutions, inclusive governance, and equitable access to digital resources. It concludes by outlining policy direction that promotes responsible AI adoption, strengthened data governance, and international collaboration to build more resilient, transparent, and sustainable food systems.

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1. Introduction

Food security, encompasses its four pillars, availability, access, utilization and stability, is one of the inevitable and unresolved challenges confronting the international community in the present. Regardless of policy commitment, unprecedented technological advancement, sustained multilateral commitment, the world is still struggling to end hunger (SDG 2). Around 733M people faced hunger in 2023, one in eleven people globally and one in five people in Africa. It is estimated that approximately 582M people will be chronically undernourished by 2030 following the current trends (Unicef, 2024).

Integration of digital technologies (RS, AI and Big data) and food governance system have emerged as potential solutions to achieve food security. AI, remote sensing, machine learning and big data analytics have fundamentally transformed the capacity of governments international organizations and agricultural sector to monitor food production systems, soil health detection, disease control, forecast supply disruptions and enabled the researchers and policymakers to develop efficient policies. Building a more sustainable food system to reduce food insecurity and uncertainty in the global food markets require concurrent near-real-time and reliable crop information for decision making. It is within this imperative that remotely sensed satellite data of crops has become the primary method of deriving crop information at local regional and global levels, revealing spatial and temporal dimensions of crop growth status and production.(Wu *et al*., 2023) .

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Revolutionary potential of these technologies is substantial and well documented. Remote sensing and artificial intelligence when integrated with climate smart agriculture can improve agriculture resilience, production and sustainability, through AI's capacity for predictive analytics, crop modeling and precision agriculture alongside remote sensing in climate projections, land management and continuous surveillance (Mmbando, 2025)**.** FAO uses remote sensing data to monitor global production of food and climate impact on food systems quite often, tracking crop yields, drought conditions and soil moisture at a global scale. (Li *et al*., 2025)**.**

Vast amount of structured and unstructured data from diverse origins is generally referred to as big data. Availability of this big data allows researchers and policymakers to delve deeper resulting in improved decision-making (Marvin *et al*., 2017)**.** Big data analytics enhancing agricultural productivity by optimizing the resources, improving crop management, irrigation scheduling, fertilization and pest control using IoT integrated systems. Yet there is underutilization of this revolutionary technology due to certain limitations (Hussein *et al*., 2025)**.** Big data analytics enables early warning systems that allow anticipation of food crisis before acute circumstances. WFP's Vulnerability Analysis Mapping (VAM) unit uses earth observation data to monitor the impact of natural disasters, armed conflicts, extreme weather events and agricultural production while simultaneously monitoring global and regional production to predict the area of concern (Buczkowski, 2022).

Regardless of all these advancements, the use of data system and AI in food security policy is neither transparent nor equitable. Some key factors complicate the translation of technological potential into policy impact such as substantial governance, ethical and access-related challenges, and digital divide. A consistent digital divide means that the benefits of these technologies are concentrated in a disproportionate way across advanced nations, while food insecure population is still deprived of these resources. This digital divide is due to the unequal access to AI technology, shortage of field experts and qualified workers in AI development and administration, the potential benefits of AI can be limited by impediments to the effective and secure deployment of AI technologies. This requires the development of well-organized sophisticated policy framework to provide standards for governance of data privacy and the ethics of AI development. (Folorunso *et al*., 2024)**.**

The ethical and governance problems are multiplied as they are tied to issues of data sovereignty, transparency and accountability. The crop monitoring system has a lot of economic value in the marketplace when the public reports are issued but there is concern that crop monitoring systems will not release unfavorable reports from the sites, the algorithms and underlying data that produced these reports are most often not available for independent review. (Wu *et al*., 2023)**.** International policy frameworks have begun responding to the emerging challenges presented by agricultural AI applications like precision farming, crop monitoring/surveillance and climate resilient crops but there is still a considerable gap, such as inadequate technological infrastructure, limited data accessibility, skill deficit and persistent ethical concerns which together demand policy frameworks aimed at mitigating the risks while optimizing socio-economic and environmental interests (Omotayo *et al*., 2025)**.**

The current chapter has two related goals. The first goal is to provide a thorough analysis of how remote sensing, AI, big data, and predictive analytics are transforming food security monitoring, providing early warnings, and designing agricultural policies. The second goal is to analyze governance and ethical challenges to data access, digital inequality, algorithmic accountability, and data sovereignty, which affect the fair and effective use of these tools.

2. Literature Review

The convergence of data systems and artificial intelligence (AI) with food security policy has emerged as one of the most significant developments at the intersection of technological innovation and humanitarian governance. Over the past decade, scholarly interest in the application of remote sensing, big data analytics, machine learning, and predictive modelling has expanded rapidly, reflecting the growing recognition that

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digital technologies can reshape the way governments, international organizations, and agricultural institutions monitor and respond to food security challenges.

The literature reviewed in this chapter focuses primarily on studies published between 2015 and 2025 and examines five interrelated themes: remote sensing and crop monitoring; big data analytics and early warning systems; artificial intelligence and predictive modelling; digital technologies in developing-country contexts; and the governance, ethical, and data-access challenges associated with these innovations. For analytical clarity, the discussion is organized into two broad strands: first, the contribution of AI and big data to food security assessment and forecasting, and second, the role of remote sensing in supporting evidence-based food security policy.

Early research established the conceptual and analytical foundations for AI-driven food security assessment. Using Bayesian Network (BN) probabilistic reasoning with Global Food Security Index (GFSI) data, How *et al*. (2020) demonstrated that predictive simulations of critical food security scenarios could be generated without requiring advanced programming expertise, thereby providing policymakers with a practical decision-support tool. Building on this line of inquiry, Bostanci *et al*. (2025) introduced the Food Security Vulnerability Index (FSVI) for Africa, integrating Long Short-Term Memory (LSTM) networks, autoencoders, Random Forest (RF), XGBoost algorithms, and panel econometric techniques. Their findings showed that rising temperatures negatively affect maize production, while rainfall variability significantly influences wheat yields. These results informed multi-scenario analyses with direct implications for climate-smart agricultural policy across the Sahel, the Horn of Africa, and Southern Africa.

Although these studies illustrate the progression from relatively accessible probabilistic models to more sophisticated multimodal AI architectures, they converge on a common conclusion: technological capability alone is insufficient unless model outputs are effectively translated into institutional decision-making processes. The gap between AI innovation and practical policy implementation remains a persistent concern. A systematic review of 171 AI modelling studies by Sarku *et al*. (2023) identified three distinct patterns of stakeholder engagement: studies relying exclusively on biophysical data with no community involvement, those incorporating partial stakeholder consultation, and genuinely participatory and iterative approaches.

A particularly important observation from this review is that only a limited number of studies established complete feedback mechanisms with the communities they sought to serve. Furthermore, much of the existing research has been conducted by institutions in the Global North focusing on populations in the Global South, creating a structural imbalance that the authors characterize as a form of epistemic injustice. From an institutional perspective, Torero (2021) similarly argues that digital agricultural technologies are inherently skill-biased, productivity-biased, and voice-biased. According to the FAO perspective, the inclusive adoption of AI requires complementary investments in regulatory systems, human capital development, and accountable governance structures. Together, these studies underscore that AI is not a self-executing solution; rather, its effectiveness depends fundamentally on the institutional environments in which it is deployed.

The relationship between digital development and food security has also been examined from a macroeconomic perspective. Novak and Kobets (2023) analyzed 111 countries using self-organizing maps based on GFSI dimensions, the Global Connectivity Index, and added agricultural value. Their regression results indicated that each advancement along the digitalization continuum from “Absence” to “Starter,” and from “Starter” and “Adopter” to “Frontrunner” improved a country’s GFSI ranking by an average of 5.6 positions. At the same time, a one-percentage-point increase in agricultural value added as a share of GDP reduced digital connectivity by approximately half a position. Extending this discussion, Ahmad *et al*. (2024) synthesized evidence on AI applications in crop surveillance, disease detection, irrigation management, and supply-chain optimization. Their review identified inadequate infrastructure, financial constraints, limited data availability, and weak regulatory frameworks as the principal barriers to AI adoption in developing countries. Collectively, these findings reveal a persistent cycle in which economies with the greatest dependence on agriculture often face the highest levels of food insecurity while simultaneously possessing

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the least capacity to benefit from AI-enabled solutions, highlighting the need for targeted international policy support.

Alongside AI, remote sensing has become a cornerstone of contemporary food security monitoring by enabling researchers and policymakers to map and assess agricultural landscapes across extensive geographic areas. Shi *et al*. (2022) evaluated national food security trends in Egypt over multiple years and reported a gradual decline in food security conditions. The satellite imagery employed in the study achieved 82% crop identification accuracy, while yield estimates remained within 5% of FAO estimates. The study further observed that the excessive use of fertilizers and agrochemicals was contributing to land degradation and declining agricultural productivity, reinforcing the need for timely policy interventions.

The policy relevance of remote sensing is also evident in crop-specific monitoring applications. Shams Esfandabadi *et al*. (2022) employed Google Earth Engine (GEE) and MODIS datasets to analyze a decade of rice production data in northern Iran. Their results showed that a hybrid Vegetation Health Index (VHI) outperformed conventional standalone vegetation indices in predicting rice yields. By linking yield forecasting with broader issues of food security, supply-chain management, and index-based agricultural insurance, the study demonstrated the potential of remote sensing to support more informed and targeted policy decisions.

Despite these operational advances, the literature also highlights important technical limitations in remote sensing-based stress detection. A systematic review of 115 studies conducted by Wen *et al*. (2020) found that conventional vegetation indices exhibit inconsistent performance in characterizing crop responses to drought and salinity, with reported coefficients of determination ranging from $R^2 = 0.02$ to 0.80. This limitation is particularly significant given that drought and salinity are projected to affect approximately half of the world's cultivated land by 2050. The review further revealed substantial overlaps between the spectral signatures of drought and salinity stress, making simultaneous differentiation technically challenging. Although plant functional traits, particularly osmotic characteristics, demonstrated stronger and more consistent relationships with salinity stress, existing remote sensing systems are not yet capable of measuring these traits directly. To address these shortcomings, the authors recommend the integration of radiative transfer models and multi-sensor frameworks. Their analysis points to a notable disparity between the theoretical capabilities of remote sensing technologies and their reliable operational application in crop health monitoring.

Beyond technical constraints, one of the least explored areas in the existing scholarship concerns the governance gap between remote sensing capabilities and their incorporation into agricultural policy. Despite more than three decades of remote sensing research and the widespread expansion of Earth observation programs, only a limited number of operational information services have been established in Sub-Saharan Africa. Notable examples include the AGRHYMET early warning system and the FAO Desert Locust Information Service. According to Bégué *et al*. (2020), this gap cannot be explained solely by data availability. Instead, it reflects the absence of effective co-construction processes that bring together remote sensing scientists, operational service providers, and policy end-users. Consequently, the challenge is no longer simply generating data but creating institutional mechanisms capable of translating technological advances into meaningful, inclusive, and context-specific food security policies.

3. Policy framework

3.1. Conceptual and Theoretical Framework

The challenges identified in the preceding section require more than a single theoretical lens to analyze adequately. This section aims to show three inter-related frameworks that together guide the analysis: sociotechnical systems theory, which situates digital tools within broader social and institutional context; digital sovereignty and data governance theory, which foregrounds the political economy of food security data and evidence- based policy translation models, which help examine the conditions under which data derived knowledge achieves or fails to achieve the policy impact.

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3.2. Sociotechnical Systems Theory: Digital Tools as Social Artefacts

A foundational premise is that remote sensing satellites, machine learning models, and AI driven early warning systems are not neutral instruments they are socio-technical artefacts whose design and deployment shape what food insecurity is rendered visible, measurable and practical (MacKenzie & Wajcman, 1999; Smith, 1988). The concept of co-production developed within Science and Technology Studies, holds the way societies know and represent the world are inseparable from the way they govern it (Callon, 1999). Applied to food security this means that AI crop monitoring systems and big data platforms reconstitute what food security looks like determining which populations are legible, which pathways are foregrounded, and which policy responses are implied by the system's outputs (Araújo *et al*., 2023; D'Ignazio & Klein, 2020). Populations where data availability is a challenge are often the most chronically food insecure since they are underrepresented by AI-driven assessments precisely because they generate fewer of the digital signals these systems are designed to process (Sarku *et al*., 2023).

The multilevel perspective on sociotechnical transitions further shows the structural dynamics of digital tool adaption in food governance, distinguishing between the niche level where innovations such as machine learning crop models are piloted, the governance level where established institutional mandates and data standards prevail within organizations such as FAO and WFP, and ground level where political pressures including SDG framework and donor priorities shape the broader policy environment (Geels, 2020). The literature on the digital divide reveals that disparities persist not only in access and use of digital technologies but also in the ability of individuals and communities to derive benefits from them, with disadvantaged groups more likely to experience exclusion and limited outcomes from digital transformation (Lythreatis *et al*., 2022). Actor-Network Theory helps explain how algorithm-based systems can become central points in food governance that everyone must rely on. These systems gain authority over decisions, even though they are not always open to proper scrutiny. This is especially relevant to concerns that crop monitoring algorithms are often not accessible for independent review (Cresswell *et al*., 2010; Neisser, 2014).

3.3. Digital Sovereignty and Political Economy of Food Security Data

The concept of digital sovereignty which originate in debates over internet governance and national control over digital infrastructure address a concrete governance problem in food security, the agricultural, nutritional and climate data that underpin policy decisions are increasingly generated, processed and stored privately or foreign controlled systems whose governance arrangements largely escape the authority of the governments most dependent on their outputs (Clapp & Ruder, 2020). This comprises of three levels. At national level it concerns whether LMIC governments (Low- and Middle-income Countries) retain meaningful data generated within their territories or whether it migrates to foreign cloud platforms or donor managed systems (Dencik *et al*., 2019). At the institutional level, it involves the international bodies including IPC, FEWS NET, and GIEWS that set data standards and access protocols in global food information systems (Amar *et al*., 2026). At the knowledge level it raises the question of whose analytical models and assumptions are encoded into the AI systems that classify and communicate food insecurity to governments (D'Ignazio & Klein, 2020; Iazzolino & Stremlau, 2024)

3.4. Evidence to Policy Translation: From data to Decision

Even where digital tools produce robust, real-time evidence on food security, such evidence does not automatically translate into policy action. The evidence-to-policy translation literature (Cairney & Oliver, 2017; Nutley *et al*., 2007) provides theoretical tools to explain this persistent gap.

Multiple streams framework is particularly instructive about policy change such that policy change occurs not when evidence is most scientifically compelling, but when a problem stream (a politically recognized crisis), a policy stream (technically feasible solutions), and a politics stream (a government agenda) converge at a single point (Asante, 2023).

A critical extension of this framework concerns the digital mediation effect: the observation that algorithmic systems do not merely transmit evidence but actively construct its framing which determines which

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indicators should have the priority, which populations are visible, and which policy responses are implied. Porter's (1995) idea of " trust in numbers" analysis shows that algorithmically generated outputs carry the appearance of scientific objectivity that can prevent questioning the assumptions behind the models or noticing populations missing due to data gaps (Levy, 2001). Similarly, the typology of research uses instrumental, conceptual and symbolic show that the influence of remote sensing or machine learning crop forecasts is rarely direct. Instead, these tools often shape what governments see as credible or urgent in food security discussions over time (Blewden *et al*., 2010).

3.5. Synthesis

The three frameworks outlined above are complementary to each other. Sociotechnical system theory reveals that digital tools are never institutionally neutral they come with embedded assumptions about what food insecurity is perceived and who is responsible for addressing it.

Digital sovereignty theory shows the political economy of food data, attending to structural asymmetries in who produces, controls and benefits from food security information. Evidence to policy translation models trace the politically mediated pathways through which digital insights can be made or fail to facilitate in meaningful idea in government decision making. Together, they provide integrated analytical architecture for examining the goals mentioned in the introduction: understanding the transformative capacity of digital tools for food security monitoring, analyzing the governance and ethical challenges surrounding data access and algorithmic accountability, and identifying the conditions under which equitable and effective data governance frameworks can be built.

4. Methodology

This section outlines the approach underpinning the analysis presented in this chapter. Given that the chapter addresses a multi-dimensional problem, the integration of digital tools, data systems and AI into food security policy is insufficient. Therefore, the methodology is structured around qualitative, drawing from literature review, secondary data analysis and comparative policy analysis. This approach is consistent with the established practice in policy research, where the complexity of governance questions requires connectivity across multiple data sources and analytical approaches.

4.1. Research Design

This chapter approaches a qualitative interpretive research design oriented towards understanding how, why and under what conditions digital technologies shape food security governance outcomes.

Rather than generating new primary data, it synthesizes and analyzes existing empirical evidence, policy documents, and institutional reports to develop theoretically grounded insights applicable across different national and institutional levels. The design focuses on three goals established in the introduction. The first goal is to analyze how remote sensing, AI, big data, and prediction analysis are transforming food security monitoring is addressed through a synthesis of peer reviewed empirical literature. The second goal is to examine governance and ethical challenges including data access, digital inequality, and algorithmic accountability draws on comparative analysis of institutional frameworks and policy documents from international organizations. The third goal is to develop an actionable framework and data governance food security policy that is addressed though case synthesis in context of governance models drawn from both high- and low-income countries. These three analytical moves correspond to a descriptive analytical normative progression common in policy oriented academic literature (Head, 2010).

4.2. Data Sources

The primary evidence base consists of peer reviewed journal articles and book chapters published predominantly between 2015 and 2025, reflecting the period of most intensive development and deployment of AI and remote sensing food security contexts.

The relevant literature was searched through Google Scholar, Scopus and Web of Science using search terms combining 'food security' with 'artificial intelligence', 'remote sensing', 'big data, 'machine learning', 'early

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warning systems', 'data governance' and 'digital divide'. The literature review covers a range of country level crop mapping studies, systematic reviews of AI modelling approaches in food security and analyses remote sensing performance in crop health monitoring. Studies were selected based on methodological rigor, geographic and thematic relevance and recency, with preference given to studies which provided quantitative assessments of tool performance or governance outcomes.

A second category of sources comprises reports, frameworks and technical manuals and strategic documents produced by the key international organizations operating at the intersection of digital technology and food security. These include the Food and Agriculture Organization of the United Nations (FAO), the world Food Program (WFP), the Integrated food security phase classification (IPC), the Famine Early Warning Systems Network (FEWS NET), the Global Information and Early Warning System on Food and Agriculture (GIEWS), and the United Nations Conference on Trade Development (UNCTAD). These documents are treated not only as sources but as data, showing normative assumptions, institutional priorities and power relations embedded in international food data governance (Prior, 2003).

To avoid abstraction, the analysis is grounded in case evidence drawn from specific country and regional settings referenced in the literature. These include Sub-Saharan Africa, Iran (Rice yield monitoring using GEE and MODIS), India and China (Irrigated Agriculture Reporting). These cases are not treated as representative samples but as illustrations that reveal broader structural patterns in the relationship between digital tool capability and food policy governance (Flyvbjerg, 2006).

4.3. Limitations

Several limitations of the methodological approach should be acknowledged, as they impact the chapter's findings. A secondary synthesis relying on published literature and organization documents are bound by existing evidence base, which may reflect structural biases in academic knowledge production. As shown in literature review, the majority of AI and remote sensing research in food security is conducted by Global North institutions about Global South populations having limited co-construction involving local researchers, communities, or policymakers. The analysis is therefore subject to the same biases it aims to critique.

The chapter's temporal scope primarily 2015 to 2025 captures a period of rapid technological change in which capabilities, development contexts, and governance of AI and remote sensing have evolved considerably. Some findings from earlier literature are necessary to build basis of analysis as well as context however, they may not accurately reflect the current state of tools or institutional frameworks, particularly given the pace of development in large language models, satellite imagery and international governance negotiations. Comparative analysis is necessarily selective. A comprehensive review of national level food data governance frameworks across all UN member states is beyond the scope of a single chapter.

The country and institutional cases selected are intended to be illustrative of broader patterns, and readers should show caution in generalizing from specific regional or national governance models without additional empirical grounding. Lastly, the chapter does not engage in primary research such that no original surveys, interviews, field observations or remote sensing analysis are conducted. This limits the capacity to make claims about the ground situation experiences of food insecure populations or on the ground implementations of digital tools,

5. Results and Discussions

The literature review resulted in three major converging streams of evidence regarding the role of digital tools, data systems and artificial intelligence (AI) in food security policy. Empirical findings from the studies focusing on these themes are given below in tables. (1) Remote sensing in precision agriculture, crop monitoring and decision making at multiple scales, (2) AI and big data analysis improving the accuracy and timeliness of food insecurity measurement and early warning, (3) Role of digital platforms and data governance frameworks in shaping food systems, their management and governance.

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Besides the benefits of these technological advancements there exists a considerable disproportion in distribution and digital divide, Global South remains underrepresented both in terms of research and technology deployment. The following subsections present synthesized empirical findings from the reviewed literature, organized thematically and supported by summary tables.

Table 17.1 Key Studies on Remote Sensing Applications in Food Security and Agricultural Policy

Title	Journal	Key Findings	Reference
Applying Tipping Point Theory to Remote Sensing Science to Improve Drought Monitoring and Food Security Early Warning	Earth's Future	Remote sensing allows policymakers to design crisis response policies by enhancing early warning for food security, disease detection in vegetation and marking the critical points.	(Krishnamurthy R *et al*., 2020)
A review of remote sensing applications in agriculture for food security: Crop growth and yield, irrigation, and crop losses	Journal of Hydrology	Remote sensing allows yield estimation and irrigated area mapping which supports policymakers to develop tailored and efficient policies and resource allocation to enhance global food availability	(Karthikeyan *et al*., 2020)
A Review of Remote Sensing Challenges for Food Security with Respect to Salinity and Drought Threats	Remote Sensing	This study identified the limitation of remote sensing detecting stressed crops urging policy investment in spectral indices for food security in stress prone areas	(Wen *et al*., 2020)
Estimating yields of household fields in rural subsistence farming systems to study food security in Burkina Faso	Remote Sensing	Remote sensing has the ability to predict the yield before harvest, which can help policymakers to identify the climate affected, small landholders to get benefits from government's policies.	(Karst *et al*., 2020)
Probabilistic forecasting of remotely sensed cropland vegetation health and its relevance for food security	Science of The Total Environment	Satellite imagery integrated probabilistic VHI forecasts aid early warning systems for sound interventions during vegetation stress	(Hammad & Falchetta, 2022)
Satellite forecasting of crop harvest can trigger a cross-hemispheric production response	Communications Earth & Environment	Yield forecasting at appropriate time can reduce fluctuation in price in importing countries, enhances trade policies and securing food availability	(Tanaka *et al*., 2023)

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Table 17.2: Selected Studies on AI, Big Data, and Digital Technologies for Food Security Policy

Title	Journal	Key Findings	Reference
IoT, big data and artificial intelligence in agriculture and food industry	IEEE Internet of Things	AI, IoT and social media have capacity to turn the work of weeks into minutes and seconds, detection and surveillance through sensors is improving yield and supply chain in agri food systems. Social media is also playing a pivotal role in connecting masses, turning the policy into more efficient and robust policy.	(Misra *et al*., 2020)
Predictive Insights for Improving the Resilience of Global Food Security Using Artificial Intelligence	Sustainability	AI modeling with big data allows users to make worst case scenarios as future projections that direct policymakers to make policies to mitigate these worst-case scenarios and secure the resources.	(How *et al*., 2020)
Artificial intelligence, big data, and blockchain in food safety	IJFE	These technologies are improving farm level operations, processing and trade related operations making policies robust and efficient	(Zhou *et al*., 2022)
Making food systems more resilient to food safety risks	Comprehensive Reviews in Food Science and Food Safety	Climate change is one of the biggest drivers of food security risks, AI and big data analytics can accurately detects the disease posing threat to food security	(Mu *et al*., 2024)
Transforming Agrifood Supply Chains with Digital Technologies	Operations Research Forum	Industry 4.0 technologies can revolutionize the agriculture food system and supply chain, by detecting microbial level contaminations, food frauds, and chemical traceability, helping decision makers to take sound measures and targeted policy interventions.	(Plakantara & Karakitsiou, 2025)

6. Conclusion

This chapter presents a holistic approach to understanding food security policy with the lens of artificial intelligence, digital tools and big data analysis. Food security has multi-dimensions, it cannot be attained by traditional methods, but it can be addressed by integrating primary and secondary data, technological fusion with ground data and future projections to make the food security policy efficient and robust, besides these advancements some concerns are very critical and posing limitations towards achieving food security.

Most of the research is done by the global north nations on the global south nations without local feedback incorporated in it which makes them far away from real-world scenarios. To avoid this one suggestion may help, global north nations can help global south nations by supporting them technically and financially and allowing them to use their resources for their own, to do research and draw results by incorporating the local stakeholders and their feedback. As they are the inhabitants and are directly influenced by the climatic and political conditions of these regions.

To mitigate hunger, it is crucial to end this digital divide and make an honest and equal proportion of benefits of AI and other technologies as most of their benefits are centered in urban and developed nations. There are less opportunities both in terms of institutions and infrastructure and in policies. There is a need to uplift the local scholars, to train them and make them work for their local community, which may contribute to the big picture of food security.

Food security also possesses a political and geopolitical background; to uplift the developing nations of global south it is crucial to keep the national interest at first place no matter which party is ruling a certain

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country, regardless of their inclination towards certain projects, food security should be considered as the most important project, technical and institutional investments and collaboration with developed countries in AI, big data and digital tools for monitoring and surveillance is of great importance.

Food security policy is dynamic, there is a need for experts in policymaking sectors in collaboration with researchers, scientists and politicians and analysts that consider local and geo-politics and take the local community onboard while decision making. This way a particular developing country may have robust policy for food security and can mitigate hunger while eliminating the digital divide, securing its data sovereignty and making it accessible to most of its population.

References

Ahmad, A., Liew, A. X., Venturini, F., Kalogeras, A., Candiani, A., Di Benedetto, G., Ajibola, S., Cartujo, P., Romero, P., & Lykoudi, A. (2024). AI can empower agriculture for global food security: challenges and prospects in developing nations. *Frontiers in artificial intelligence*, *7*, 1328530. https://doi.org/10.3389/frai.2024.1328530

Amar, S., Bori, N., & Cörvers, R. (2026). From collection to control: Data governance, digital technologies, and the politics of inclusion in the digitalisation of smallholder agriculture. *Outlook on Agriculture*, *55*(1), 19-27. https://doi.org/10.1177/00307270251410944

Araújo, S. O., Peres, R. S., Ramalho, J. C., Lidon, F., & Barata, J. (2023). Machine Learning Applications in Agriculture: Current Trends, Challenges, and Future Perspectives. *Agronomy*, *13*(12), 2976. https://www.mdpi.com/2073-4395/13/12/2976

Asante, W. (2023). The multiple streams framework and forest policy change process in Ghana. *Cogent Social Sciences*, *9*(1), 2228062. https://doi.org/10.1080/23311886.2023.2228062

Bégué, A., Leroux, L., Soumaré, M., Faure, J.-F., Diouf, A. A., Augusseau, X., Touré, L., & Tonneau, J.-P. (2020). Remote sensing products and services in support of agricultural public policies in Africa: Overview and challenges. *Frontiers in Sustainable Food Systems*, *4*, 58. https://doi.org/10.3389/fsufs.2020.00058

Blewden, M., Carroll, P., & Witten, K. (2010). The use of social science research to inform policy development: case studies from recent immigration policy. *Kōtuitui: New Zealand Journal of Social Sciences Online*, *5*(1), 13-25. https://doi.org/10.1080/1175083X.2010.498087

Bostanci, S. H., Kantar, G., & Yildirim, S. (2025). AI-Based Assessment of Food Security and Climate Change: Multi-Scenario Analysis for Africa. *IEEE Access*, *13*, 205991-206005. https://doi.org/10.1109/ACCESS.2025.3639349

Buczkowski, A. (2022). *How satellite data is contributing to global food security*. https://geoawesome.com/eo-hub/how-satellite-data-is-contributing-to-global-food-security/

Cairney, P., & Oliver, K. (2017). Evidence-based policymaking is not like evidence-based medicine, so how far should you go to bridge the divide between evidence and policy? *Health Research Policy and Systems*, *15*(1), 35. https://doi.org/10.1186/s12961-017-0192-x

Callon, M. (1999). The Role of Lay People in the Production and Dissemination of Scientific Knowledge. *Science, Technology and Society*, *4*(1), 81-94. https://doi.org/10.1177/097172189900400106

Clapp, J., & Ruder, S.-L. (2020). Precision Technologies for Agriculture: Digital Farming, Gene-Edited Crops, and the Politics of Sustainability. *Global Environmental Politics*, *20*(3), 49-69. https://doi.org/10.1162/glep_a_00566

Cresswell, K. M., Worth, A., & Sheikh, A. (2010). Actor-Network Theory and its role in understanding the implementation of information technology developments in healthcare. *BMC Medical Informatics and Decision Making*, *10*(1), 67. https://doi.org/10.1186/1472-6947-10-67

D'Ignazio, C., & Klein, L. F. (2020). *Data feminism*. MIT Press. https://doi.org/10.7551/mitpress/11805.001.0001

Dencik, L., Hintz, A., Redden, J., & Treré, E. (2019). Exploring Data Justice: Conceptions, Applications and Directions. *Information, Communication & Society*, *22*, 873-881. https://doi.org/10.1080/1369118X.2019.1606268

Flyvbjerg, B. (2006). Five misunderstandings about case-study research [Article]. *Qualitative Inquiry*, *12*(2), 370-387. https://www.scopus.com/pages/publications/33645708913

Folorunso, A., Olanipekun, K., Adewumi, T., & Samuel, B. (2024). A policy framework on AI usage in developing countries and its impact. *Global Journal of Engineering and Technology Advances*, *21*(01), 154-166.https://doi.org/10.30574/gjeta.2024.21.1.0192

Geels, F. W. (2020). Micro-foundations of the multi-level perspective on socio-technical transitions: Developing a multi-dimensional model of agency through crossovers between social constructivism, evolutionary economics and neo-institutional theory. *Technological Forecasting and Social Change*, *152*, 119894. https://doi.org/10.1016/j.techfore.2019.119894

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Hammad, A. T., & Falchetta, G. (2022). Probabilistic forecasting of remotely sensed cropland vegetation health and its relevance for food security. *Science of the Total Environment*, *838*, 156157. https://doi.org/10.1016/j.scitotenv.2022.156157

Head, B. W. (2010). Reconsidering evidence-based policy: Key issues and challenges. *Policy and Society*, *29*(2), 77-94. https://doi.org/10.1016/j.polsoc.2010.03.001

How, M.-L., Chan, Y. J., & Cheah, S.-M. (2020). Predictive Insights for Improving the Resilience of Global Food Security Using Artificial Intelligence. *Sustainability*, *12*(15), 6272. https://www.mdpi.com/2071-1050/12/15/6272

Hussein, J. B., Workneh, T. S., Kassim, A., Ntsowe, K., Melesse, S. F., & El-Mesery, H. S. (2025). A review on the impact of big data analytics in transforming agricultural practices, food processing, and preservation strategies. *Applied Food Research*, *5*(2), 101234. https://doi.org/10.1016/j.afres.2025.101234

Iazzolino, G., & Stremlau, N. (2024). AI for social good and the corporate capture of global development. *Information Technology for Development*, *30*, 1-18. https://doi.org/10.1080/02681102.2023.2299351

Karst, I. G., Mank, I., Traoré, I., Sorgho, R., Stückemann, K.-J., Simboro, S., Sié, A., Franke, J., & Sauerborn, R. (2020). Estimating yields of household fields in rural subsistence farming systems to study food security in Burkina Faso. *Remote Sensing*, *12*(11), 1717. https://doi.org/10.3390/rs12111717

Karthikeyan, L., Chawla, I., & Mishra, A. K. (2020). A review of remote sensing applications in agriculture for food security: Crop growth and yield, irrigation, and crop losses. *Journal of hydrology*, *586*, 124905. https://doi.org/10.1016/j.jhydrol.2020.124905

Krishnamurthy R, P. K., Fisher, J. B., Schimel, D. S., & Kareiva, P. M. (2020). Applying tipping point theory to remote sensing science to improve early warning drought signals for food security. *Earth's future*, *8*(3), e2019EF001456. https://doi.org/10.1029/2019EF001456

Levy, E. (2001). Quantification, Mandated Science and Judgment. *Studies in History and Philosophy of Science Part A*, *32*(4), 723-737. https://doi.org/10.1016/S0039-3681(01)00019-X

Li, L., Wang, J., Wang, X., Peng, P., Shen, J., Zhu, H., & Zhang, Z. (2025). Big data and data science in global governance: anticipating future needs and applications in the UN and beyond [Review]. *Frontiers in Political Science*, *Volume 7 - 2025*. https://doi.org/10.3389/fpos.2025.1583772

Lythreatis, S., Singh, S. K., & El-Kassar, A.-N. (2022). The digital divide: A review and future research agenda. *Technological Forecasting and Social Change*, *175*, 121359. https://doi.org/10.1016/j.techfore.2021.121359

MacKenzie, D., & Wajcman, J. (1999). *The Social Shaping of Technology*. Open University. https://researchonline.lse.ac.uk/id/eprint/28638/

Marvin, H. J., Janssen, E. M., Bouzembrak, Y., Hendriksen, P. J., & Staats, M. (2017). Big data in food safety: An overview. *Critical reviews in food science and nutrition*, *57*(11), 2286-2295. https://doi.org/10.1080/10408398.2016.1257481

Misra, N. N., Dixit, Y., Al-Mallahi, A., Bhullar, M. S., Upadhyay, R., & Martynenko, A. (2020). IoT, big data, and artificial intelligence in agriculture and food industry. *IEEE Internet of things Journal*, *9*(9), 6305-6324.https://doi.org/10.1109/JIOT.2020.2998584

Mmbando, G. S. (2025). Harnessing artificial intelligence and remote sensing in climate-smart agriculture: the current strategies needed for enhancing global food security. *Cogent Food & Agriculture*, *11*(1), 2454354. https://doi.org/10.1080/23311932.2025.2454354

Mu, W., Kleter, G. A., Bouzembrak, Y., Dupouy, E., Frewer, L. J., Radwan Al Natour, F. N., & Marvin, H. (2024). Making food systems more resilient to food safety risks by including artificial intelligence, big data, and internet of things into food safety early warning and emerging risk identification tools. *Comprehensive Reviews in Food Science and Food Safety*, *23*(1), e13296. https://doi.org/10.1111/1541-4337.13296

Neisser, F. M. (2014). 'Riskscapes' and risk management – Review and synthesis of an actor-network theory approach. *Risk Management*, *16*(2), 88-120. https://doi.org/10.1057/rm.2014.5

Novak, O., & Kobets, V. (2023). Artificial intelligence impact on food security of states in the world. International Conference on Information and Communication Technologies in Education, Research, and Industrial Applications.https://icteri.org/icteri-2023/proceedings/preview/01000237.pdf

Nutley, S. M., Walter, I., & Davies, H. T. O. (2007). Index. In *Using evidence: How research can inform public services* (pp. 0). Policy Press.

Omotayo, A. O., Adediran, S. A., Omotoso, A. B., Olagunju, K. O., & Omotayo, O. P. (2025). Artificial intelligence in agriculture: ethics, impact possibilities, and pathways for policy. *Computers and Electronics in Agriculture*, *239*, 110927. https://doi.org/10.1016/j.compag.2025.110927

Plakantara, S. P., & Karakitsiou, A. (2025). Transforming Agrifood Supply Chains with Digital Technologies: a Systematic Review of Safety and Quality Risk Management. Operations Research Forum.https://doi.org/10.1007/s43069-025-00511-3

Prior, L. (2003). *Using Documents in Social Research* [Book]. Sage Publications Ltd.https://www.torrossa.com/en/resources/an/4913877

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Sarku, R., Clemen, U. A., & Clemen, T. (2023). The Application of Artificial Intelligence Models for Food Security: A Review. *Agriculture*, *13*(10), 2037. https://www.mdpi.com/2077-0472/13/10/2037

Shams Esfandabadi, H., Ghamary Asl, M., Shams Esfandabadi, Z., Gautam, S., & Ranjbari, M. (2022). Drought assessment in paddy rice fields using remote sensing technology towards achieving food security and SDG2. *British Food Journal*, *124*(12), 4219-4233. https://doi.org/10.1108/BFJ-08-2021-0872

Shi, S., Ye, Y., & Xiao, R. (2022). Evaluation of Food Security Based on Remote Sensing Data Taking Egypt as an Example. *Remote Sensing*, *14*(12), 2876. https://www.mdpi.com/2072-4292/14/12/2876

Smith, J. K. (1988). The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology. Edited by Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch. Cambridge, Mass.: MIT Press, 1987. 405 pp. Illustrations, charts, notes, bibliography, and index. $35.00. *Business History Review*, *62*(2), 341-342. https://doi.org/10.2307/3116018

Tanaka, T., Sun, L., Becker-Reshef, I., Song, X.-P., & Puricelli, E. (2023). Satellite forecasting of crop harvest can trigger a cross-hemispheric production response and improve global food security. *Communications Earth & Environment*, *4*(1), 334. https://doi.org/10.1038/s43247-023-00992-2

Torero, M. (2021). Robotics and AI in food security and innovation: why they matter and how to harness their power. In *Robotics, AI, and humanity: Science, ethics, and policy* (pp. 99-107). Springer. https://doi.org/10.1007/978-3-030-54173-6_8

Unicef. (2024). The state of food security and nutrition in the world 2024. https://openknowledge.fao.org/handle/20.500.14283/cd1254en

Wen, W., Timmermans, J., Chen, Q., & van Bodegom, P. M. (2020). A review of remote sensing challenges for food security with respect to salinity and drought threats. *Remote Sensing*, *13*(1), 6. https://doi.org/10.3390/rs13010006

Wu, B., Zhang, M., Zeng, H., Tian, F., Potgieter, A. B., Qin, X., Yan, N., Chang, S., Zhao, Y., Dong, Q., Boken, V., Plotnikov, D., Guo, H., Wu, F., Zhao, H., Deronde, B., Tits, L., & Loupian, E. (2023). Challenges and opportunities in remote sensing-based crop monitoring: a review. *Natl Sci Rev*, *10*(4), nwac290. https://doi.org/10.1093/nsr/nwac290

Zhou, Q., Zhang, H., & Wang, S. (2022). Artificial intelligence, big data, and blockchain in food safety. *International journal of food engineering*, *18*(1), 1-14. https://doi.org/10.1515/ijfe-2021-0299

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CHAPTER 18

Aligning Food Security with SDGs and Climate Commitments

Muhammad Haroon U Rashid[1,2,*], Irfan Ahmad[1], Umar Aftab Abbasi[1], Muhammad Umair Sial[3] & Kinza Khaliq[1]
[1]Department of Forestry and Range Management, University of Agriculture, Faisalabad, 38000, Pakistan
[2]Chinese Fir Engineering Technology Research Center of State Forestry Administration, College of Forestry, Fujian Agriculture and Forestry University, Fuzhou, 350002, China
[3]Department of Entomology, University of Agriculture, Faisalabad, 38000, Pakistan
Corresponding authors' email: haroon.r@uaf.edu.pk

Abstract

The food security of developing economies is at a crossroads. Millions of people still experience hunger and malnutrition even though agricultural production is aggravated by climate change. The increasing temperatures, erratic rainfall, droughts, and floods endanger crop yields, soil quality, and livelihoods. In the meantime, agriculture is also a significant source of greenhouse gases, and food systems are both victims and contributors to climate change in a complex cycle. These two problems require radical, composite, and future-looking policies. This chapter addresses the multidimensional nature of food security through the four pillars of food security: availability, access, utilization, stability, and socioeconomic and institutional environments that lead to results in the developing world. It emphasizes the importance of international mechanisms, such as the Sustainable Development Goals and the Paris Agreement, in finding the right balance between national policies, climate obligations, and development priorities. This correspondence is reflected in the creation of new strategies. As ways to create resilient, productive, and low-carbon food systems, climate-smart agriculture, agroforestry, sustainable land and water management, biodiversity conservation, and food loss and waste reduction are discussed. The potential of scientific and technological innovations, such as precision farming or crop varieties that are resistant to unfavorable climate conditions and digital solutions, has never been as high as it is now, to transform agricultural activities. This is also essential in the face of inclusive and sustainable socioeconomic and institutional interventions such as policy integration, capacity building among farmers, gender equity and value chains. The chapter combines climate adaptation, mitigation, and food security to give a roadmap on how the developing economies can develop resilient and equitable food systems. It focuses on evidence-based, practical policy solutions and strategies that will assist in maximizing the synergies, reducing trade-offs, and empowering communities. Harmonizing food security and climate action has thus become an imperative rather than an option, requiring coherent, cross-sectoral policies that safeguard food availability, livelihoods, and environmental sustainability for present and future generations.

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1. Introduction

Food security has been one of the most pressing concerns in developing economies, where rapid population growth, resource shortages, and socioeconomic disparities have posed challenges for food systems. To this day, a large portion of the world's population lacks stable access to adequate, safe, and nutritious food, even though agricultural productivity has significantly increased over the last several decades (Ogwu *et al*., 2024). Another cause of this issue is climate change, which shifts temperature regimes, intensifies extreme weather events, and alters agricultural production patterns. Therefore, sustainable food security is no longer just an agricultural issue but a multidimensional policy issue that traverses the environmental sustainability and global development agendas (Battersby, 2018).

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The integration and inclusive development planning took a major step when the United Nations adopted the Sustainable Development Goals. Specifically, SDG 2 (Zero hunger) and SDG 13 (Climate Action) emphasize the immediate need to address food insecurity and combat climate change (Atukunda *et al*., 2021). Along with this, the Paris Agreement has strengthened international commitment to reducing greenhouse gas emissions and increasing adaptive capacity, which have direct effects on agricultural systems and food production. Nevertheless, most developing nations have policy frameworks that address food security and climate change issues in isolation from one another, with little chance of realizing synergies (Leahy *et al*., 2020).

It is an urgent and strategic need to align the food security policies with the Sustainable Development Goals and climate commitments. This kind of alignment can benefit governments through co-benefits, such as increased agricultural resilience, carbon sequestration, and sustainable resource management (Cohen *et al*., 2021). Climate-smart agriculture, agroforestry, and nature-based solutions are approaches that can combine productivity, adaptation, and mitigation targets. However, this alignment will take place only after institutional fragmentation is overcome by enhancing the effectiveness of governance institutions and ensuring adequate financing and technology are in place (Shebanina *et al*., 2024).

This chapter examines the interfaces between food security, the Sustainable Development Goals, and climate commitments, with specific attention to developing economies. It employs an analytical framework that traces how climate change affects the four pillars of food security (availability, access, utilization, and stability), how SDG implementation shapes food system outcomes, and how mitigation and adaptation interact, including potential synergies and trade-offs. It examines the conceptual interconnections, enumerates the major policy issues, and identifies ways to promote coherence between sectors. The chapter seeks to strengthen and sustain a food system that can support current and future needs in the face of variable climatic changes.

1.1. Concepts, Dimensions, and Determinants of Food Security: Understanding Food Security

Food security is a multidimensional phenomenon that has transformed over the years to encompass availability, access, utilization, and stability of food. The Food and Agriculture Organization defines food security as a situation in which everyone, at all times, has physical, social, and economic access to adequate, safe, and nutritious food that meets their dietary needs and preferences, enabling them to live an active and healthy life. This definition emphasizes the importance of the quantity and quality of food, as well as socioeconomic factors influencing access. In developing countries, food security is also closely linked to poverty reduction, agricultural development, and resilience to environmental and economic crises (Shakeel, 2018).

Table 18.1: Four Pillars of Food Security

Pillar	Key Determinants	Global Indicators/Facts
Availability	Agricultural productivity, land use, trade policies and food aid	**828 million:** Estimated number of people facing hunger globally due to supply disruptions and climate shocks
Access	Household income, market proximity, food prices and infrastructure	**High-Price Volatility:** In developing nations, households may spend over 50-70% of their income on food.
Utilization	Clean water access, sanitation, nutrition education, and healthcare	**Stunting:** Affects roughly 22% of children under 5 globally due to poor nutrient uptake and sanitation.
Stability	Climate resilience, political stability, and income steady states	**Climate Impact:** Extreme weather events have increased by 400% since the 1980s, threatening long-term food stability.

1.2. Determinants of Food Security

Food security in developing economies is a complicated interaction of environmental, economic and socio-political elements. The key factors include the productivity of agriculture, availability of land and water, climate as well as technological advancements. Specifically, climate change is a critical menace to crop production, water availability, and the occurrence of extreme events. (Onyenekwe *et al*., 2022).

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The availability of food directly relates to economic characteristics such as income distribution, labor availability, and food prices, and to governance, policy frameworks, and institutional capacity that define the success of food security interventions. Social factors, including education, gender equality, and cultural practices, are also significant in shaping food use and nutritional outcomes (Nhamo *et al*., 2022).

These determinants need to be addressed in a holistic manner in order to come up with policies that do not only amplify food production but also balance access and sustainability with the growing environmental and socioeconomic demands.

2. Climate Change and Food Systems: The effects, emissions, and vulnerability of developing economies

The global food system is slowly changing due to climate change, and some of the worst impacts have been felt in developing economies, where agriculture is extremely climate-sensitive. The rising temperatures altered rainfall patterns, and the increasing frequency and intensity of extreme weather events such as droughts, floods, and heatwaves are disrupting agricultural production (Narayan *et al*., 2024). Besides reducing crop production, these climatic stresses alter crop quality, soil fertility, and water availability, thereby undermining the overall resilience of farm systems. In rain-fed agricultural areas that make up a major part of the developing world, even slight changes in climate can drastically affect food production and rural livelihoods. In addition, climate shocks disrupt supply chains, cause unstable prices, and lead to food insecurity. Consequently, agricultural systems must be shifted towards more adaptive and resilient systems to maintain food security in changing environmental conditions (Jha & Dev, 2024).

Food systems and climate change are in a complex, reciprocal relationship, despite their vulnerability, as agriculture is also a significant source of greenhouse gas emissions. Enteric fermentation in livestock and rice production, nitrous oxide (N_2O) caused by the excessive use of nitrogen-based fertilizers, and carbon dioxide (CO_2) due to land-use changes, especially deforestation and land degradation, are the major sources of methane, nitrous oxide, and carbon dioxide, respectively (Küfeoğlu, 2024). The percentage of global emissions attributed to agriculture, forestry, and other land use (AFOLU) has been high, as per the Intergovernmental Panel on Climate Change. The causes of carbon footprint of the sector also include some unsustainable farming practices such as overuse of chemical inputs, monocropping, and poor land stewardship. To overcome these problems, sustainable land management, nutrient-use efficiency, and carbon sequestration (e.g., agroforestry and conservation agriculture) policies need to be enforced (Loboguerrero *et al*., 2019).

The developing countries are structurally vulnerable to climate change. More prone to use agriculture as a source of income and economic stability, but less diversified because of the lack of funds, inefficient infrastructure, and access to technology, these countries are also less versatile. The smallholder farmers who form the agricultural production backbone of most developing areas are especially prone. Inadequate access to credit, extension facilities, varieties that are resistant to climate, and irrigation systems diminish their ability to respond to climatic shocks and adapt to a changing environment. In addition, weak performance of response is attributed to dysfunctional institutional structures, lack of cohesion in policies, and lack of funding in agricultural research and climate change adaptation. Poverty, inequality and lack of education are socioeconomic issues that compound vulnerability and the communities that suffer environmental shocks have a hard time recovering. (Thakur *et al*., 2024).

Technological, institutional, and socioeconomic interventions should be part of the process of developing resilience in developing economies. Adaptive capacity can be greatly improved through climate-smart agriculture, improved access to climate information services, capacity building, and financial tools, such as climate funds and insurance tools. This will require reinforcement of governance, enhanced policy coherence, and inclusion of vulnerable populations in development strategies. Governance quality, institutional effectiveness, and political incentives are critical determinants of whether technical and environmental solutions translate into sustained food security outcomes; without addressing these political economy dimensions, even well-designed interventions risk limited uptake and poor long-term impact. Finally, it is important to address the coupled problem of climate change and food systems to achieve

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sustainable food security and sustainable development amid growing environmental uncertainty (Silici *et al*., 2021).

3. Food Security: SDG Framework Interlinkages, Synergies, and Trade-offs

3.1. SDG 2 – Zero Hunger

Goal 2 of the Sustainable Development Goals, Zero Hunger, is one of the pillars of the global development agenda, focusing on eliminating hunger, achieving food security, and enhancing nutrition and sustainable agriculture by 2030. It is a holistic reflection of the fact that food security goes beyond simple increases in food production to encompass equitable access, nutritional quality, and the long-term sustainability of food systems. Here, SDG 2 focuses on the quantity of food produced, its accessibility and affordability, and its capacity to meet the dietary needs of different populations (Atukunda *et al*., 2021).

One of the challenges addressed by SDG 2 is the elimination of all forms of malnutrition, including undernourishment, micronutrient deficiencies, and the rising rates of diet-related non-communicable diseases. This underscores the significance of diversified food, better food use, and better health interventions for the population. Moreover, the goal highlights the importance of increasing the agricultural productivity and incomes of small-scale food producers, especially smallholder farmers, women, and indigenous peoples, who are crucial to food production in the developing world. Improving livelihoods and achieving inclusive growth requires improving their access to land, inputs, financial services, markets, and technology (Hiywotu, 2025).

The second important aspect of SDG 2 is the encouragement of sustainable and resilient agricultural development. Climate change poses a significant threat to food production systems, and there is therefore an urgent need to adopt strategies that increase adaptive capacity and minimize environmental impacts. The SDG 2 sustainable agriculture practices involve the efficient use of resources, the protection of soil and biodiversity, and the minimization of chemical inputs. Such measures will not only result in productivity in the long run but also protect natural resources (Lile *et al*., 2023).

SDG 2 has been a major challenge in developing countries due to high population growth, poverty, insufficient infrastructure, and vulnerability to climate change. The issue of food insecurity is a major concern for the population, particularly in rural areas where agriculture is a key income-generating activity. The situation is exacerbated by conflicts, economic uncertainties, and market upheavals. Therefore, SDG 2 is possible with local, national, and global activities, which are integrated and coordinated. It is important to improve policy frameworks, invest in agricultural research and innovation, develop rural infrastructure, and reinforce the social protection system. By addressing the underlying causes of hunger and ensuring environmental sustainability and resilience, SDG 2 can assist developing economies in attaining food security and improved nutrition through sustainable food systems (Atukunda *et al*., 2021; Hiywotu, 2025).

3.2. Linkages with SDG 1, 3, 6, 12, 13, and 15

As a concept, food security is cross-cutting, as it is closely associated with many of the Sustainable Development Goals. These interlinkages highlight that food security is not an objective in itself but must be built on a broad continuum of socioeconomic and environmental dimensions.

SDG 1 (No Poverty) stands out especially, and poverty is a significant barrier to food access. Poverty is a major impediment to food security because poor households can hardly afford proper, healthy food. Speaking of which, SDG 3 (Good Health and Well-being) closely connects to nutrition, as malnutrition and micronutrient deficiencies, as well as an increased number of diet-related diseases, are outcomes of poor diets (Feliciano, 2019).

SDG 6 (Clean Water and Sanitation) is crucial to food production and consumption. Water is important for irrigation, livestock, and food processing, and for preparing food safely and utilizing nutrients properly; access to clean water and sanitation is needed. The unavailability of adequate water resources and sanitation systems leads to poor agricultural productivity and poor human health (Küfeoğlu, 2022).

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In addition, SDG 12 (Responsible Consumption and Production) aims to minimize food loss and waste and improve the efficiency of natural resources throughout the food supply chain. It is particularly so in the developing world, where even after the harvest, post-harvest losses consume the food supply. SDG 13 (Climate Action) relates to both the direct and indirect impacts of climate change on food systems, including crop production, water supply, and the occurrence of extreme events (Campbell *et al*., 2018).

Additionally, SDG 15 (Life on Land) emphasizes protecting terrestrial ecosystems, forests, and biodiversity because they play a crucial role in sustaining agricultural productivity and ecosystem services, such as pollination and soil fertility (Wang *et al*., 2020).

These interrelations have shown that integrated, coordinated policy responses are necessary to achieve food security. By addressing these linkages, one can generate synergies, enabling numerous development objectives to be achieved simultaneously and ensuring long-term development sustainability.

3.3. SDGs Synergies and Trade-offs

Interrelations among the SDGs can create synergies but may also introduce trade-offs. For example, sustainable agriculture can improve food production, mitigate climate change, and protect biodiversity. Agroforestry and climate-smart agriculture are among the approaches that can help achieve the SDGs 2, 13, and 15.

Some of the policies aimed at increasing food production, however, have side effects, including deforestation, water depletion, and greenhouse gas emissions. Key trade-offs that policymakers must navigate include: agricultural intensification versus biodiversity conservation; irrigation expansion versus long-term water sustainability; biofuel production versus food availability; and emission reduction targets versus productivity objectives for smallholder farmers. Likewise, the need to increase farmlands can be counterproductive to the aim of preserving the ecosystems. Therefore, such trade-offs must be carefully managed by policymakers through evidence-based planning and integrated systems (Figure 18.1). Coherence across sectors needs to be fostered, and national strategies need to be aligned with global goals to achieve maximum synergies and sustainability in food security and environmental protection. (Xiao *et al*., 2023).

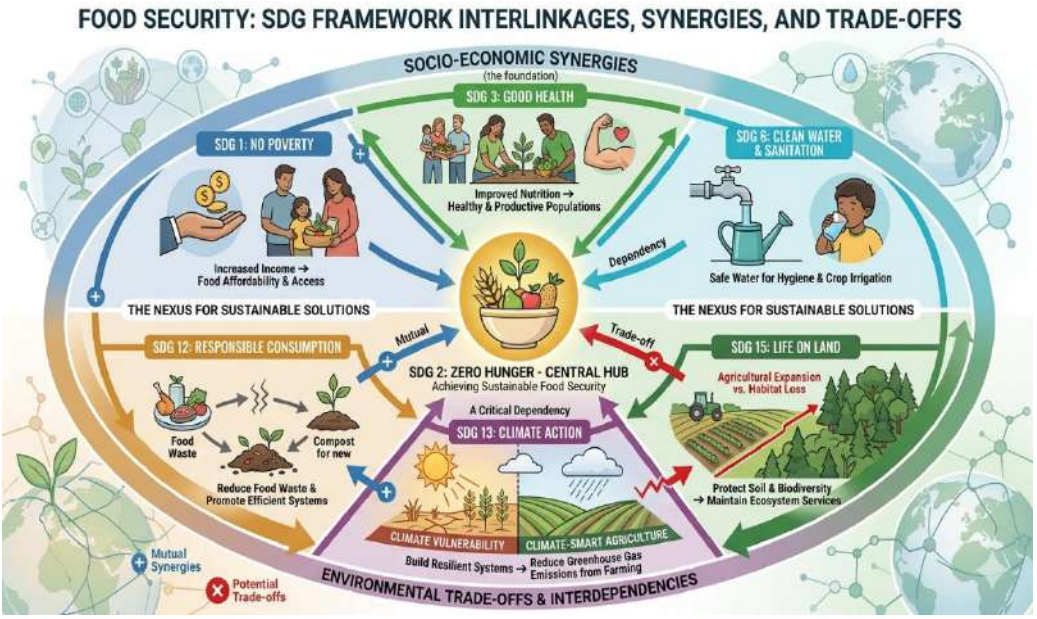
FOOD SECURITY: SDG FRAMEWORK INTERLINKAGES, SYNERGIES, AND TRADE-OFFS
SOCIO-ECONOMIC SYNERGIES
(the foundation)
SDG 3: GOOD HEALTH
SDG 1: NO POVERTY
SDG 6: CLEAN WATER & SANITATION
Improved Nutrition → Healthy & Productive Populations
Increased Income → Food Affordability & Access
Dependency
Safe Water for Hygiene & Crop Irrigation
THE NEXUS FOR SUSTAINABLE SOLUTIONS
THE NEXUS FOR SUSTAINABLE SOLUTIONS
SDG 12: RESPONSIBLE CONSUMPTION
Mutual
Trade-off
SDG 15: LIFE ON LAND
SDG 2: ZERO HUNGER - CENTRAL HUB
Achieving Sustainable Food Security
Agricultural Expansion vs. Habitat Loss
A Critical Dependency
SDG 13: CLIMATE ACTION
Food Waste
Compost for new
Reduce Food Waste & Promote Efficient Systems
Protect Soil & Biodiversity → Maintain Ecosystem Services
CLIMATE VULNERABILITY
CLIMATE-SMART AGRICULTURE
Build Resilient Systems →
Reduce Greenhouse Gas Emissions from Farming
Mutual Synergies
Potential Trade-offs
ENVIRONMENTAL TRADE-OFFS & INTERDEPENDENCIES

Figure 18.1: Theoretical Model

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This theoretical model portrays SDG 2 (Zero hunger) as the center, with the necessary synergies of environmental and socioeconomic stability. It highlights the balancing act required to balance global food security with trade-offs in climate action and land conservation.

4. Global Climate Commitments and Policy Frameworks

Climate change is one of the greatest threats to food security, agricultural productivity, and sustainable development worldwide. Global warming, experienced worldwide due to increased temperatures, altered precipitation patterns, and extreme weather conditions, is interfering with agricultural production systems. They are especially dramatic in the developing world, where agriculture is the livelihood of the rural population and the mainstay of the national economies (IPCC, 2022; FAO, 2023). Climate change affects crop productivity, soil fertility, water availability, and pest dynamics, posing significant risks to food production and food supply chains (Schmidhuber and Tubiello, 2007; Wheeler and Von Braun, 2013). However, food systems and agriculture are also major sources of worldwide greenhouse gas (GHG) emissions. The agriculture, forestry, and other land use sectors also contributes about 21-24 percent of anthropogenic GHG emissions around the world, such as the emission of methane because of livestock and rice cultivation, nitrous oxide because of fertilized soils, and carbon dioxide because of land-use change (IPCC, 2022; Crippa *et al*., 2021; OECD, 2024). Attributing the entire food system (processing, transport, and consumption) to emissions may account for up to 1/3 of global emissions (Mukherji *et al*., 2024). The dual nature of agriculture as both a cause and a consequence of climate change has contributed to the growing acceptance of the need to integrate climate mitigation and adaptation policies with food security policies. International climate governance systems are significant for informing national and international efforts to address these problems. The main international policy instruments include the Paris Agreement, Nationally Determined Contributions, the Koronivia Joint Work on Agriculture, and national adaptation and mitigation plans, all under the United Nations Framework Convention on Climate Change (UNFCCC). These frameworks present a policy framework to align climate commitments with the Sustainable Development Goals, particularly Zero Hunger (SDG-2) and Climate Action (SDG-13).

4.1. Paris Agreement

The Paris Agreement is a historic global accord adopted in 2015 to combat climate change by aligning mitigation and adaptation efforts. The agreement stipulates the long-term aim of cutting global warming to well below 2 o C above pre-industrial levels, and targets 1.5 o C. This would be achieved through large reductions in GHG emissions at the international level and by increasing adaptive capacity in vulnerable sectors, including agriculture, water resources, and ecosystems. One of the few unique aspects of the Paris Agreement is its recognition of the strong link between climate change and food security. The necessity of protecting food production systems and responding to climate change is explicitly emphasized in the agreement, stating that mitigation and adaptation policies must not undermine agricultural productivity. It is a pointer to the increasing panic that climate change will lead to significant upheaval in the global food supply systems (Rogelj *et al*., 2016; IPCC, 2023).

Climate change can affect agricultural production in various ways. The increase in temperature can lower crop yield by increasing plant respiration rates and shortening crop development time (Rezaei *et al*., 2023). Alterations in rainfall patterns may lead to prolonged droughts or excessive flooding, threatening agricultural productivity and soil quality. Also, climate change may increase pest, weed, and disease populations, further undermining food production systems (Wheeler and Von Braun, 2013; IPCC, 2022). In this scenario, the Paris Agreement promotes the uptake of climate-smart agriculture (CSA) practices that can improve agricultural productivity, resilience to climate variability, and GHG emissions reduction (Lipper *et al*., 2014; FAO, 2023). Some of the CSA practices are conservation agriculture, better irrigation practices, integrated nutrient management, agroforestry, and sustainable livestock production. Agroforestry systems can greatly increase carbon sequestration while raising soil fertility, biodiversity, and farm productivity. Recent research has shown that the agroforestry systems have the potential to sequester 0.5-5 Mg of carbon per hectare per year, in addition to offering economic gains and stabilizing farm incomes (Abbas *et al*., 2026). Moreover, the Paris Agreement facilitates global collaboration through climate finance schemes, including the Green

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Climate Fund, as well as technology transfer and capacity-building programs that help vulnerable countries develop climate-resilient agriculture (Buchner *et al*., 2013; FAO, 2023).

4.2. Nationally Determined Contributions (NDCs).

One of the key mechanisms for implementing the Paris Agreement is the Nationally Determined Contributions (NDCs) system. These national climate action plans describe each country's commitments to reducing GHG emissions and adapting to the effects of climate change. In contrast to previous international treaties, NDCs allow countries to set their own climate goals based on national priorities, economic factors, and technological possibilities (UNFCCC, 2021). NDCs have been broadly inclusive of agriculture and food systems due to their susceptibility to climate change and their national economic and food security significance. According to recent studies, over 90 percent of developing nations also have agriculture as a priority sector in their climate adaptation NDCs (FAO, 2023). Typical farm adaptation measures described in NDCs are:

- Production of climate-resistant plant types.
- Better irrigation and water management system.
- Land restoration and soil conservation programs.
- Integrated pest management.
- Early warning systems and climate information.

These actions are meant to strengthen agricultural systems to climate variability without reducing food production. In addition to adaptation policies, most NDCs include mitigation policies to reduce agricultural emissions. The significant contributors to agricultural emissions are methane from livestock and rice production, and nitrous oxide from fertilizer use (Crippa *et al*., 2021; IPCC, 2022). These emissions can be greatly minimized through better manure management and application, precision fertilization, and sustainable livestock feeding practices without reducing productivity (Smith *et al*., 2020; OECD, 2024). Although agriculture has been increasingly included in NDCs, implementation has been a challenge. The majority of developing countries are financially constrained and have limited institutional capacity, and they cannot access climate technologies. To transform NDC commitments into agricultural climate action, therefore, there is a need to improve global collaboration, climate financing, and capacity-building efforts (Buchner *et al*., 2013; FAO, 2023).

4.3. Nationally Adaptation and Mitigation Strategies

Global climate objectives established by international agreements are implemented by national governments through national adaptation and mitigation strategies. Many countries have developed National Adaptation Plans (NAPs) and sectoral climate policies in reaction to the vulnerability of agricultural systems to the effects of climate change. The national adaptation plans also aim to increase the resilience of agricultural systems through better water management, the development of climate-resistant crop varieties, diversification of agricultural systems, and the rehabilitation of degraded lands. The measures enable farmers to manage climate variability and ensure stable food production (IPCC, 2022; FAO, 2023).

The mitigation measures aim to reduce greenhouse gas emissions in the agricultural sector. Conservation agriculture, agroforestry, better grazing management, and the restoration of degraded ecosystems are among the major strategies. These plans help minimize emissions and improve ecosystem services such as soil fertility, water retention, and biodiversity conservation (Smith *et al*., 2020; Lee and Ignaciuk, 2025). The idea of food system transformation is gaining increasing importance in recent policy debates, as it addresses the effects of climate change across the entire food supply chain, including production and consumption. Food systems can also significantly influence the environment by minimizing environmental footprints through reduced food loss and waste, improving supply chain efficiency, and promoting sustainable diets (Willett *et al*., 2019; FAO, 2023). Food waste alone accounts for about 8% of global GHG emissions, underscoring the significance of systemic strategies to reduce GHG emissions in food systems (UNFCCC, 2021). National climate strategies should be properly coordinated at the institutional level with the sectors involved in the process, such as agriculture, forestry, water resources, and rural development. The policies

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on climate and food security should be combined so that mitigation actions do not impact food production, and adaptation work is made more resilient for agriculture (Figure 18.2).

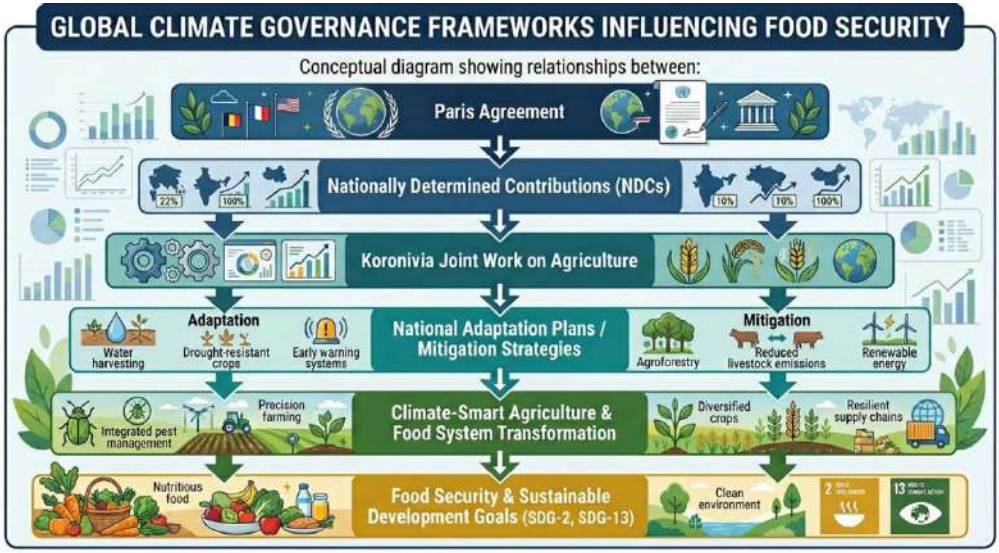

Figure 18.2: Global Climate Governance

4.4. Aligning Food Security with Climate Action Strategies

Food security should be aligned with climate action in an integrated, holistic manner that covers agricultural productivity, environmental sustainability, and climate risk resilience. In developing economies, where food systems are highly susceptible to climatic variability, strategic interventions should aim at adaptation and mitigation, with a focus on long-term sustainability (Olarewaju *et al*., 2025).

One framework that has played a significant role in these goals is climate-smart agriculture (CSA). CSA enhances productivity and climate adaptation and mitigation practices, including crop diversification, improved nutrient management, and more efficient resource use. Not only do these practices stabilize yields under changing climatic conditions, but they also reduce greenhouse gas emissions (Matteoli *et al*., 2020).

Land and soil management should also be sustainable, as they are the basis of agricultural productivity. Soil fertility, water retention, and carbon storage can be enhanced through conservation tillage, soil organic amendments, and land restoration practices. The approaches are relevant in reversing the tide of land degradation and rendering agricultural systems sustainable in the long term (Shah & Wu, 2019).

Agroforestry can be a viable option for combining food production and environmental preservation. Planting trees in agroforestry systems can address biodiversity and soil health requirements and achieve considerable carbon sequestration. This is particularly true in developing countries, where these systems provide numerous livelihood and ecological benefits. Water resource management is another crucial aspect, especially in regions with water shortages. Water use can be made efficient through effective irrigation techniques, rainwater harvesting, and integrated watershed management, and agricultural production can be sustained even in the face of changing climatic conditions. (Raj *et al*., 2019).

The resilience of food systems is also enhanced by biodiversity conservation, which helps sustain the ecosystem services necessary for food production, such as pollination, pest control, and nutrient cycling. Conservation and augmentation of biodiversity make agricultural systems more resilient to environmental changes (Figure 18.3).

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Sustainable livestock systems are also crucial for reducing the environmental footprint of farming. The adoption of better feeding programs, livestock breeding systems, and integrated livestock-crop systems can boost productivity and reduce greenhouse gas emissions.

Lastly, minimizing food loss and waste is a cost-effective way to enhance food access and does not place an additional burden on natural resources. Enhancing supply chains, storage infrastructure, and responsible eating can greatly improve the effectiveness of food systems (Singh *et al*., 2025).

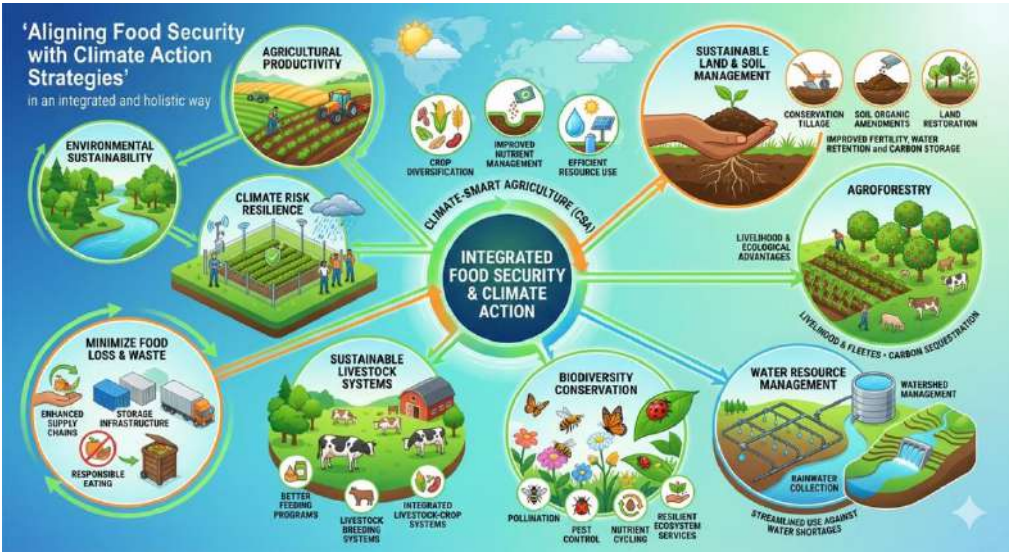

Figure 18.3: Food Security and Climate Action Strategies

4.5. Innovation and Technology

The key to changing the food systems and making them climate-oriented is technological progress and innovation. Over the past few years, the advent of digital technologies in agriculture has opened new possibilities to improve productivity, efficiency, and resilience. Precision agriculture allows farmers to make the most of their inputs, including water, fertilizers, and pesticides, with the help of sensors, satellite photos, and data analytics. A more developed method like this can help minimize waste, reduce production costs, and reduce environmental impacts. Digital and smart farming technologies can also help inform decisions by providing real-time information on weather, soil health, and crop performance. Farmers will have access to timely information through remote sensing, climate advisory services, and mobile applications, thereby enhancing risk management and productivity. Emerging applications of artificial intelligence in agriculture, including predictive crop modeling, pest detection, and yield forecasting, alongside blockchain-enabled traceability systems and digital advisory platforms, are increasingly shaping climate-resilient food systems by improving supply chain transparency and smallholder market access. Moreover, better crop varieties should also be introduced, including drought- and climate-resistant varieties, to adapt to the shifting climatic and environmental conditions. Plant breeding and biotechnology have led to higher yields, improved nutrition, and resistance to pests and diseases (Osumba *et al*., 2021; Pimenow *et al*., 2025).

4.6. Opportunities and Future Directions

A combination of food security and climate action will offer developing economies an innovative opportunity to build a resilient and sustainable food system. Economic development and environmental sustainability can be co-opted in order to meet a number of objectives, including more productivity, less pollution, and better living standards. The new generation will have to invest in research and innovation, in particular in technologies and nature-based solutions more resistant to climate change. It will require establishment of

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institutional competence and governance systems to be policy competent and coordinating. Additionally, international cooperation and knowledge exchange can also be significant in solving common problems and following best practices. They will prevent the exclusion of any part of the population by including growth, participatory strategies, and evidence-based policymaking. Lastly, technological innovation, sustainable management of resources and effective institutional support should be put together as one to help achieve food security and climate commitments. This kind of approach will assist developing countries to deal with the complex problems of the 21 st century and be able to provide future generations with food security and environmental sustainability (Figure 18.4).

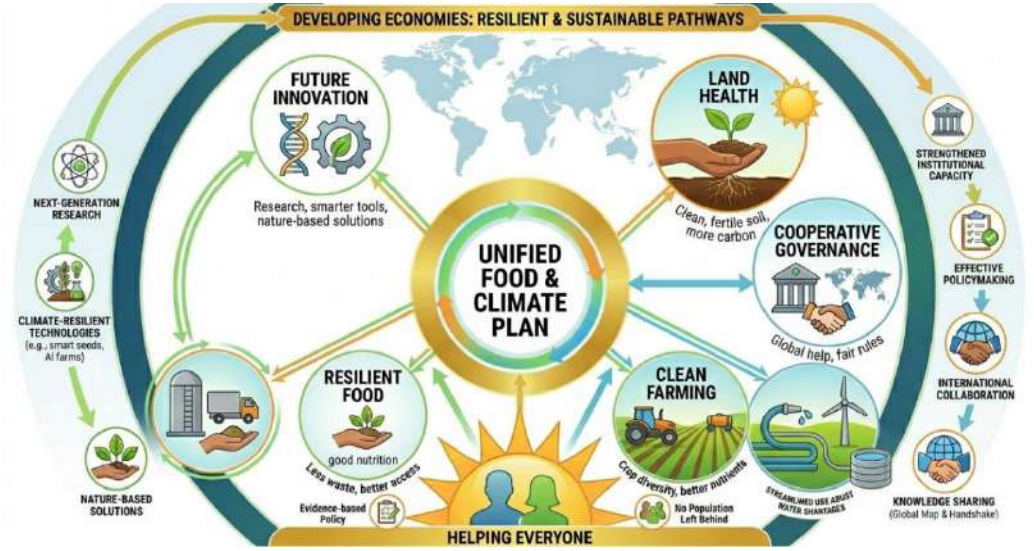

Figure 18.4: Resilient and Sustainable Pathways

5. Policy Recommendations

Attaining food security-climate action alignment will need consistent, integrated, and proactive policy frameworks organized across multiple actors and levels of governance. National governments should ensure policy coherence by integrating NDC commitments into national agricultural plans, providing financial incentives for climate-smart agriculture (CSA) and agroforestry, and enacting gender-inclusive land tenure reforms to secure equitable access for women and marginalized smallholders (expected outcome: reduced policy fragmentation and improved adaptive capacity). International organizations and development partners should scale up climate finance through the Green Climate Fund and blended finance mechanisms, while supporting technology transfer of precision agriculture, remote sensing, and digital advisory services to farmers in developing economies (expected outcome: accelerated adoption of climate-resilient technologies). Agricultural research institutions should prioritize the development of drought-tolerant and heat-resistant crop varieties, generate regionally differentiated evidence on CSA performance across South Asia, Sub-Saharan Africa, Southeast Asia, and Latin America, and strengthen climate information services for smallholders (expected outcome: context-specific, evidence-based interventions). Firstly, policy consistency between sectors should be in place. It will aid in establishing additional synergies and reducing trade-offs between national agricultural policies and climate commitments (through frameworks such as the Paris Agreement) and national agricultural policies and development priorities (through the Sustainable Development Goals). This needs good institutional coordination, transparent governance, and a long-term strategy. Second, more investments in climate-resilient agriculture are required. Financial incentives, subsidies, and availability of credit should enable governments to promote the use of climate-smart agriculture, agroforestry, and sustainable land management practices. Improved research and development systems will also contribute towards accelerating innovation and the spread of adaptive technologies. Third,

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capacity of farmers and extension services needs to be enhanced. The farmers can be empowered through training programs and climate advisory services coupled with knowledge sharing platforms to embrace sustainable practices and enhance productivity in face of the changing climatic conditions. Special focus will be the smallholder farmers who tend to be the most vulnerable. Fourth, inclusive gender and social inequality policies have to be promoted. To achieve a great deal with respect to food security and livelihoods in rural locations, women and marginalized groups should have equitable access to land, resources, technology and markets. Fifth, this can strengthen market systems and value chains which are more efficient and minimize food loss. This will boost the food distribution and income of the farmers through investing in infrastructure, storage and transportation systems and market availability. Finally, evidence-based decision-making necessitates data, monitoring and governance systems improvements. The implementation of policies and evaluation can be effective by providing credible data on climate change impacts, indicators of agricultural productivity, and food security.

6. Conclusion

Food security and climate change are structurally intertwined challenges that demand coordinated, long-term policy responses rather than parallel, sector-specific initiatives. The central finding of this chapter is that meaningful alignment between food security objectives and climate commitments is achievable, but contingent on governance effectiveness, adequate financing, and context-sensitive strategies that reflect regional heterogeneity across South Asia, Sub-Saharan Africa, Southeast Asia, and Latin America. This chapter has already discussed the intricate interplay between food systems and climate change and the need to incorporate food security into broader development agendas, such as the Sustainable Development Goals. It has also highlighted the necessity of striking a balance between synergies and trade-offs across industries and promoting sustainable and resilient agricultural practices. Some of the ways of achieving this alignment include sustainable land management, agroforestry, climate-smart farming, and technological innovation. They have managed to do so, though, because of conducive institutional structures, inclusive policies, and good governance. The shift towards sustainable food systems must be supported by a holistic approach that is well-oriented in the balance of environmental sustainability, economic viability, and social equity. International collaboration, investment in research and innovation, and empowerment of the community will have to be reinforced to address future adversities. In conclusion, climate action should be aligned with food security objectives as a strategic priority, not an afterthought. Future research should focus on quantifying trade-offs between agricultural intensification and biodiversity conservation, evaluating climate finance effectiveness in diverse institutional contexts, and generating longitudinal evidence on CSA adoption and food security outcomes across developing regions. Developing economies can offer food security not only to their citizens by taking comprehensive and sustainable strategies, but also help the world to achieve its climate targets.

References

Abbas, M. A., Asad, S., Zhang, J., Omer, A. A. A., Hassan, W. U., Ameen, M., Niu, C., & Li, Y. (2026). Agroforestry as a climate-smart economic strategy: Carbon benefits, adaptation pathways, and global evidence from smallholder systems. *Forests, 17*(2), Article 159. https://doi.org/10.3390/f17020159

Atukunda, P., Eide, W. B., Kardel, K. R., Iversen, P. O., & Westerberg, A. C. (2021). Unlocking the potential for achievement of the UN Sustainable Development Goal 2–"Zero Hunger"–in Africa: Targets, strategies, synergies and challenges. *Food & Nutrition Research, 65*, 10–29219. https://doi.org/10.29219/fnr.v65.7686

Battersby, J. (2018). MDGs to SDGs–new goals, same gaps: The continued absence of urban food security in the post-2015 global development agenda. In *Africa in the post-2015 development agenda* (pp. 115–129). Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9781315159058-7/mdgs-sdgs-new-goals-gaps-continued-absence-urban-food-security-post-2015-global-development-agenda-jane-battersby

Buchner, B., Mignucci, M. H., Trabacchi, C., Wilkinson, J., Stadelmann, M., Boyd, R., Mazza, F., Falconer, A. D., & Micale, V. (2013). *Global landscape of climate finance*. Climate Policy Initiative. https://iris.unive.it/handle/10278/43733

Campbell, B. M., Hansen, J., Rioux, J., Stirling, C. M., & Twomlow, S. (2018). Urgent action to combat climate change and its impacts (SDG 13): Transforming agriculture and food systems. *Current Opinion in Environmental Sustainability, 34*, 13–20. https://doi.org/10.1016/j.cosust.2018.06.005

© 2026 The Authors. Published under CC BY 4.0. | https://doi.org/10.66529/book.9786277945039.2026.ch18

Cohen, B., Cowie, A., Babiker, M., Leip, A., & Smith, P. (2021). Co-benefits and trade-offs of climate change mitigation actions and the Sustainable Development Goals. *Sustainable Production and Consumption, 26*, 805–813. https://doi.org/10.1016/j.spc.2020.12.034

Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F. N., & Leip, A. (2021). Food systems are responsible for a third of global anthropogenic GHG emissions. *Nature Food, 2*, 198–209. https://doi.org/10.1038/s43016-021-00225-9

FAO. (2023). *Agrifood systems in nationally determined contributions: Global analysis*. Food and Agriculture Organization of the United Nations. https://doi.org/10.4060/cd3210en

Feliciano, D. (2019). A review on the contribution of crop diversification to Sustainable Development Goal 1 "No poverty" in different world regions. *Sustainable Development, 27*(4), 795–808. https://doi.org/10.1002/sd.1923

Hiywotu, A. M. (2025). Advancing sustainable agriculture for goal 2: Zero hunger: A comprehensive overview of practices, policies, and technologies. *Agroecology and Sustainable Food Systems, 49*(7), 1027–1055. https://doi.org/10.1080/21683565.2025.2451344

IPCC. (2022). *Climate change 2022: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_LongerReport.pdf

IPCC. (2023). *Climate change 2023: Synthesis report.* Intergovernmental Panel on Climate Change IPCC, Geneva, Switzerland. https://doi.org/10.59327/IPCC/AR6-9789291691647

Jha, M. K., & Dev, M. (2024). Impacts of climate change. In *Smart internet of things for environment and healthcare* (pp. 139–159). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-70102-3_10

Küfeoğlu, S. (2022). SDG-6 clean water and sanitation. In *Emerging technologies: Value creation for sustainable development* (pp. 289–304). Springer International Publishing. https://doi.org/10.1007/978-3-031-07127-0_8

Küfeoğlu, S. (2024). Agriculture, forestry, and other land use sector emissions. In *Net zero: Decarbonizing the global economies* (pp. 157–209). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-70322-5_4

Leahy, S., Clark, H., & Reisinger, A. (2020). Challenges and prospects for agricultural greenhouse gas mitigation pathways consistent with the Paris Agreement. *Frontiers in Sustainable Food Systems, 4*, Article 69. https://doi.org/10.3389/fsufs.2020.00069

Lee, L., & Ignaciuk, A. (2025). *Mitigating climate change in the agriculture, forestry and other land use (AFOLU) sectors: A literature review on policy effectiveness* (OECD Food, Agriculture and Fisheries Papers No. 221). OECD Publishing. https://doi.org/10.1787/166b6c31-en

Lile, R., Ocnean, M., Balan, I. M., & Kiba, D. I. (2023). Challenges for zero hunger (SDG 2): Links with other SDGs. In *Transitioning to zero hunger* (pp. 9–66). MDPI. https://doi.org/10.3390/books978-3-03897-863-3-2

Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., Bwalya, M., Caron, P., Cattaneo, A., Garrity, D., Henry, K., & Hottle, R. (2014). Climate-smart agriculture for food security. *Nature Climate Change, 4*(12), 1068–1072. https://doi.org/10.1038/nclimate2437

Loboguerrero, A. M., Campbell, B. M., Cooper, P. J., Hansen, J. W., Rosenstock, T., & Wollenberg, E. (2019). Food and earth systems: Priorities for climate change adaptation and mitigation for agriculture and food systems. *Sustainability, 11*(5), Article 1372. https://doi.org/10.3390/su11051372

Matteoli, F., Schnetzer, J., & Jacobs, H. (2020). Climate-smart agriculture (CSA): An integrated approach for climate change management in the agriculture sector. In *Handbook of climate change management: Research, leadership, transformation* (pp. 1–29). Springer International Publishing. https://doi.org/10.1007/978-3-030-22759-3_148-1

Mukherji, A., Marshall, S., Arango, J., Costa, C., Flintan, F. E., Hebebrand, C., Kihara, J. M., Masso, C., Molloy, P., Rusinamhodzi, L., & Sapkota, T. B. (2024). *2024 breakthrough agenda report: Agriculture*. CGIAR, Montpellier, France. https://agriculture-breakthrough2024.cgiar.org/wp-content/uploads/2024-Breakthrough-Agenda-Report-Agriculture.pdf

Narayan, M., Singh, N., Solanki, P., & Srivastava, R. K. (2024). Impact of extreme events on global food security. In *Food security in a developing world: Status, challenges, and opportunities* (pp. 133–152). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-57283-8_9

Nhamo, L., Mpandeli, S., Liphadzi, S., & Mabhaudhi, T. (2022). Securing land and water for food production through sustainable land reform: A nexus planning perspective. *Land, 11*(7), Article 974. https://doi.org/10.3390/land11070974

Organisation for Economic Co-operation and Development. (2024). *OECD-FAO agricultural outlook 2024–2033*. OECD Publications.

Ogwu, M. C., Izah, S. C., Ntuli, N. R., & Odubo, T. C. (2024). Food security complexities in the global south. In *Food safety and quality in the global south* (pp. 3–33). Springer Nature Singapore. https://www.researchgate.net/profile/Isiko-Isaac/publication/382744836_Diseases_Transmitted_to_Humans_through_Foodborne_Microbes_in_the_Glo

© 2026 The Authors. Published under CC BY 4.0. | https://doi.org/10.66529/book.9786277945039.2026.ch18

bal_South/links/685047a1df3fa4286a40f991/Diseases-Transmitted-to-Humans-through-Foodborne-Microbes-in-the-Global-South.pdf

Olarewaju, O. O., Fawole, O. A., Baiyegunhi, L. J., & Mabhaudhi, T. (2025). Integrating sustainable agricultural practices to enhance climate resilience and food security in Sub-Saharan Africa: A multidisciplinary perspective. *Sustainability, 17*(14), Article 6259. https://doi.org/10.3390/su17146259

Onyenekwe, C. S., Okpara, U. T., Opata, P. I., Egyir, I. S., & Sarpong, D. B. (2022). The triple challenge: Food security and vulnerabilities of fishing and farming households in situations characterized by increasing conflict, climate shock, and environmental degradation. *Land, 11*(11), Article 1982. https://doi.org/10.3390/land11111982

Osumba, J. J., Recha, J. W., & Oroma, G. W. (2021). Transforming agricultural extension service delivery through innovative bottom–up climate-resilient agribusiness farmer field schools. *Sustainability, 13*(7), Article 3938. https://doi.org/10.3390/su13073938

Pimenow, S., Pimenowa, O., Moldavan, L., Prus, P., & Sadowska, K. (2025). Agroforestry as a resource for resilience in the technological era: The case of Ukraine. *Resources, 14*(10), Article 152. https://doi.org/10.3390/resources14100152

Raj, A., Jhariya, M. K., Yadav, D. K., Banerjee, A., & Meena, R. S. (2019). Agroforestry: A holistic approach for agricultural sustainability. In *Sustainable agriculture, forest and environmental management* (pp. 101–131). Springer Singapore. https://doi.org/10.1007/978-981-13-6830-1_4

Rezaei, E. E., Webber, H., Asseng, S., Boote, K., Durand, J. L., Ewert, F., Martre, P., & MacCarthy, D. S. (2023). Climate change impacts on crop yields. *Nature Reviews Earth & Environment, 4*(12), 831–846. https://doi.org/10.1038/s43017-023-00491-0

Rogelj, J., Den Elzen, M., Höhne, N., Fransen, T., Fekete, H., Winkler, H., Schaeffer, R., Sha, F., Riahi, K., & Meinshausen, M. (2016). Paris Agreement climate proposals need a boost to keep warming well below 2°C. *Nature, 534*(7609), 631–639. https://doi.org/10.1038/nature18307

Schmidhuber, J., & Tubiello, F. N. (2007). Global food security under climate change. *Proceedings of the National Academy of Sciences, 104*(50), 19703–19708. https://doi.org/10.1073/pnas.0701976104

Shah, F., & Wu, W. (2019). Soil and crop management strategies to ensure higher crop productivity within sustainable environments. *Sustainability, 11*(5), Article 1485. https://doi.org/10.3390/su11051485

Shakeel, A. (2018). Food security: Theorizing the evolution and involution of the concept. *The Arab World Geographer, 21*(1), 58–82.

Shebanina, O., Poltorak, A., & Chorniy, D. (2024). Global food security: Challenges in achieving the Sustainable Development Goals. *Ukrainian Black Sea Region Agrarian Science, 28*(4), 9–20. https://doi.org/10.56407/bs.agrarian/4.2024.09

Silici, L., Rowe, A., Suppiramaniam, N., & Knox, J. W. (2021). Building adaptive capacity of smallholder agriculture to climate change: Evidence synthesis on learning outcomes. *Environmental Research Communications, 3*(12), Article 122001. https://doi.org/10.1088/2515-7620/ac44df

Singh, N. K., Chandrakar, P., Taye, T., Singh, I. P., Singh, V. P., Bara, S., & Vithalrao, U. S. (2025). Environmental impact and mitigation approaches in livestock production systems: A review. *Archives of Current Research International, 25*(8), 351–364. https://doi.org/10.9734/acri/2025/v25i81423

Smith, P., Calvin, K., Nkem, J., Campbell, D., Cherubini, F., Grassi, G., Korotkov, V., Le Hoang, A., Lwasa, S., McElwee, P., & Nkonya, E. (2020). Which practices co-deliver food security, climate change mitigation and adaptation, and combat land degradation and desertification? *Global Change Biology, 26*(3), 1532–1575. https://doi.org/10.1111/gcb.14878

Thakur, A., Kumari, D., & Kumar, P. (2024). Climate change and agriculture: Assessing the relationship between agricultural practices, greenhouse gas emissions, and climate change. In *A comprehensive exploration of soil, water, and air pollution in agriculture* (p. 155).

UNFCCC .(2021). *Nationally determined contributions under the Paris Agreement: Synthesis report by the Secretariat*. United Nations Framework Convention on Climate Change. https://unfccc.int/documents/306848

Wang, T., Giuliani, G., Lehmann, A., Jiang, Y., Shao, X., Li, L., & Zhao, H. (2020). Supporting SDG 15, life on land: Identifying the main drivers of land degradation in Honghe Prefecture, China, between 2005 and 2015. *ISPRS International Journal of Geo-Information, 9*(12), Article 710. https://doi.org/10.3390/ijgi9120710

Wheeler, T., & Von Braun, J. (2013). Climate change impacts on global food security. *Science, 341*(6145), 508–513. https://doi.org/10.1126/science.1239402

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., & Jonell, M. (2019). Food in the Anthropocene: The EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet, 393*(10170), 447–492. https://doi.org/10.1016/S0140-6736(18)31788-4

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Xiao, H., Liu, Y., & Ren, J. (2023). Synergies and trade-offs across sustainable development goals: A novel method incorporating indirect interactions analysis. *Sustainable Development, 31*(2), 1135–1148. https://doi.org/10.1002/sd.2446

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CHAPTER 19

National Food Security Transformation in South Asia: Trends, Vulnerabilities, and Policy Pathways

Zainab Razaq[1], Muhammad Umer Farrukh[1,*], Omar Abdullah Alkhateeb[4], Faisal Munir[1], Sajjad Hyder[2,3], Sania Ahmad[1] & Motiba Ghafoor[1]
[1]Department of Economics, Faculty of Administrative and Management Sciences, Government College Women University Sialkot, Pakistan.
[2]Department of Botany, Faculty of Natural Sciences, Government College Women University Sialkot, Pakistan.
[3]INTI International University, Malaysia.
[4]Department of Agribusiness and Consumer Sciences, College of Agriculture & Food Sciences, King Faisal University, Al-Ahsa, Saudi Arabia
Corresponding authors' email: umarfarrukh@outlook.com

Abstract

Food security in South Asia remains a critical development challenge despite substantial advances in agricultural production and economic growth. This chapter reviews the conceptual evolution, theoretical foundations, measurement approaches, and empirical evidence relating to national food security, with a particular focus on Pakistan, India, and Bangladesh. It traces the transition from traditional supply-oriented perspectives toward multidimensional frameworks that incorporate availability, access, utilization, stability, agency, and sustainability. The chapter examines major theoretical approaches, including Malthusian, entitlement, livelihoods, and food systems perspectives, while highlighting the growing influence of the Sustainable Development Goals and resilience-based thinking in contemporary food security discourse. The review further evaluates the strengths and limitations of existing food security indicators and composite indices, emphasizing the need for national-level measures capable of capturing long-term structural change. Attention is given to econometric and modelling approaches, including ARDL, VECM, GARCH, and composite index methodologies, as tools for understanding food security dynamics over time. The regional evidence underscores the importance of climate change, demographic pressure, governance, and policy interventions in shaping food security outcomes across South Asia. Country-specific experiences reveal contrasting development trajectories, with Bangladesh demonstrating significant progress, India facing persistent nutrition paradoxes, and Pakistan confronting increasing vulnerabilities associated with climate shocks and institutional constraints. The chapter concludes by identifying major gaps in measurement, dynamic analysis, and comparative policy research, providing a strong foundation for a multidimensional and longitudinal assessment of national food security in South Asia.

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1. Introduction

Food Security is one of those ideas that seems simple at first, that everyone should have enough to eat but it turned out to be surprisingly deep and complex the more you look at it. Over the past few decades, the way we understand and define food security has changed quite a lot, moving from a simple focus on whether a country grows enough food to a much broader question about whether people can get, afford and benefit from food that is available. This section traces that journey.

1.1. Definition and Evaluation of the concept

The earliest thinking about food security from the 1940's through the 1970s was mostly about national food supply. Governments and international organizations measure food security by looking at how much food a country produced, if production was enough to feed the population, the country was considered food secure.

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This made sense in the context of post war reconstruction and threat of famine, when simply producing enough food was the main challenge. The focus was on agriculture and self-sufficiency: growing more wheat, growing more rice, and the problem is solved.

That view changed fundamentally in 1981 when the Nobel-Prize-winning economist Amartya Sen published his landmark book Poverty and Famines. Sen showed through careful historical analysis that some of the worst famines in history including the 1943 Bengal famine happened not because there was less food available, but because poor people could not afford it. Food was in the market; they just had no money to access it. Sen called this the 'Entitlement approach', the idea that food security depends on people's entitlement to food, not just on whether food exists (Sen, 1983). This shifted the entire conversation from supply to access.

Building on this insight, the Food and Agriculture Organization of the United Nations (FAO) developed the definition of food security that is still used today, formally adopted at the 1996 World Food Summit: food security exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2008). This definition organizes food security around four pillars: Availability (is there enough food), Access (can people afford food), utilization (does the food they eat nourish them), and stability (is food security consistent over time, or does it collapse during droughts, floods, and economic crises).

More recently, scholars have argued that even four pillars are not enough. A fifth-dimension Agency has been added in some frameworks, recognizing that people and governments need the power to make meaningful decisions about their food systems, not just passively receive whatever food is available or accessible (FAO, 2020). For a comparative study of three very different countries like Pakistan, India, and Bangladesh, this evaluation in thinking matters a great deal, it means we need a framework that captures not just food quantities, but food system, policies, governance, and sustainability.

1.2. Levels of Food Security analysis

Food security can be studied at various levels like global, regional, national, community, household and individual. Each level tells a different part of the story. A country might produce more than food nationally, while millions of people in certain regions or social groups still go hungry. India is a striking example it regularly exports food grains and holds enormous government stocks, yet it ranks near the bottom of global hunger indices. This tells us that national level food availability, though important, does not automatically translate into food security for every citizen.

So why focus on the national level at all? Because national governments are once who set food policies, manage food reserves, regulate markets, and decide how much to import or export. National level analysis Is essential for understanding how these decisions shape the food security of an entire population over time (Clapp, 2017). It is also the level at which international comparisons are most meaningful and at which data is most consistently available across countries. For Pakistan, India and Bangladesh, three countries that share historical roots but have followed very different development paths, National level comparative analysis offers a uniquely valuable insight into what works and what does not.

The Sustainable Development Goal 2 (Zero Hunger) also frames food security explicitly at the national level, setting targets for government to achieve and report on. This makes national food security analysis not just academically interesting but policy relevant in most direct sense (United Nations, 2015).

1.3. National Food Security vs Food and Nutrition Security

One important distinction that has grown in importance over recent decades is the difference between food security which means having enough calories to eat and food and nutrition security which means having access to food that is nutritious and safe. A person can be calorically sufficient but still be malnutrition if their diet lacks iron, zinc, vitamin A or other micronutrients. This condition, sometimes called hidden hunger, is extremely common in South Asia (IFPRI, 2014).

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Pakistan, India and Bangladesh all have high rates of micronutrients deficiency even in populations that are not technically undernourished in caloric terms. India's nutrition paradox, high food production, high malnutrition it's one of the most discussed puzzles in development economics. Bangladesh has reduced hunger dramatically but still faces anemia and stunting. Pakistan diet quality especially in rural areas remains poor despite adequate grain supplies. These patterns suggest that for studying national food security in South Asia must go beyond calories and include dimensions of nutrition quality, dietary diversity and utilization which is precisely what the six-dimension model used in the study is designed to do.

2. Theoretical Perspectives and Analytical Frameworks

Over the years, researchers and policymakers have approached food security from a variety of theoretical perspectives. Each framework emphasizes a different dimension of the problem while inevitably overlooking others. Understanding these perspectives is important because they shape both the interpretation of food insecurity and the policy responses designed to address it. This section reviews the major theoretical approaches and discusses their strengths and limitations, particularly in relation to the dynamic, comparative, and national-level analysis undertaken in this study.

2.1. Classical and Neo-Malthusian Perspective

The oldest and perhaps most intuitive explanation of food insecurity is rooted in the Malthusian perspective, which argues that population growth tends to outpace food production, eventually leading to shortages and famine. Thomas Malthus first articulated this argument in 1798, and variations of his theory have reappeared repeatedly in debates on food security and resource scarcity (Malthus, 1798).

In the South Asian context, population pressure remains a significant concern. India, Pakistan, and Bangladesh together account for a population approaching 1.9 billion people, all dependent on a limited and increasingly constrained agricultural land base (FAO, 2023). Pakistan's annual population growth rate of approximately 2.4 percent is among the highest in Asia, placing continuous pressure on food production systems and natural resources (Pakistan Bureau of Statistics, 2023).

However, while the neo-Malthusian perspective is useful for understanding long-term resource constraints, it does not adequately explain why food insecurity can worsen dramatically within a single year due to floods, droughts, or price shocks. Nor can it explain why one country may achieve significant improvements in food security while a neighboring country with similar natural resource endowments does not. Dynamic comparative analysis therefore requires theoretical frameworks capable of capturing change over time and variation across countries, something that the Malthusian framework alone cannot provide.

2.2. Entitlement, Livelihoods, and Food Systems Approaches

A major shift in food security thinking came with Sen's entitlement approach, which redirected attention from food production to food access. As discussed earlier, Sen argued that people experience hunger not because food is unavailable, but because they lack the economic, social, or legal means to obtain it. This insight fundamentally transformed both the academic understanding of food insecurity and the design of food policy. The central proposition that people go hungry not because food does not exist, but because they cannot access it through income, social networks, or legal rights, remains as relevant today as when Sen first introduced it (Sen, 1983).

Building on Sen's work, the Sustainable Livelihoods Framework (SLF), developed during the 1990s by researchers at the Institute of Development Studies in Sussex, provided a broader understanding of food security. The framework conceptualizes food security as an outcome of the assets available to households and communities, including natural, physical, human, social, and financial capital, together with the context of vulnerability in which these assets are utilized (Chambers & Conway, 1991). SLF was particularly important because it situated food security within the broader context of livelihoods, recognizing that the ability to obtain food depends on overall economic and social conditions rather than on food markets alone.

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More recently, the food systems approach has gained increasing prominence. Rather than focusing narrowly on food production or market access, this framework examines the entire "farm-to-fork" chain, encompassing production, processing, distribution, retail, and consumption, as well as the environmental, economic, and social factors influencing each stage (HLPE, 2017). The food systems perspective is especially valuable in the era of globalization, where food networks are highly interconnected and disruptions in one part of the world, as demonstrated during the COVID-19 pandemic, can have significant implications for food security thousands of miles away.

2.3. Food Security in the SDG and Food Systems Discourse

The adoption of the Sustainable Development Goals (SDGs) in 2015, particularly SDG 2 (Zero Hunger), brought renewed international attention to food security. SDG 2 commits countries to ending hunger, achieving food security, improving nutrition, and promoting sustainable agriculture by 2030 (United Nations, 2015). The significance of this framework lies in its emphasis on sustainability, which introduces a long-term environmental dimension that was largely absent from earlier approaches. Food security is no longer viewed solely in terms of whether people have enough food today; it also depends on whether agricultural and ecological systems can continue to provide sufficient food in the future.

This sustainability perspective is highly relevant to Pakistan, India, and Bangladesh. Pakistan's groundwater tables are declining rapidly because of excessive irrigation; India's Green Revolution regions are experiencing severe soil degradation, while aquifers in Punjab are being depleted at unsustainable rates; and Bangladesh's coastal agricultural lands are increasingly threatened by salinity intrusion resulting from rising sea levels. These are not distant or hypothetical risks but measurable and immediate threats to long-term national food security capacity that must be incorporated into any serious analytical framework for the region (Immerzeel *et al*., 2010; Pingali, 2012; Kabir & Cramb, 2019). This is one of the principal reasons why the present study extends beyond the traditional four pillars of food security by incorporating sustainability as an additional analytical dimension.

2.4. Dynamic Perspectives on Food Security

One of the most important, yet often overlooked, characteristics of food security is that it is inherently dynamic. A country that appears food secure during a year of favorable rainfall may experience a severe food crisis during a drought. Similarly, a nation that achieves food self-sufficiency through technological advances such as the Green Revolution may see those gains erode over time if investment in agriculture declines. External shocks, including global commodity price spikes, pandemics, and political instability, can dramatically alter a country's food security status within a relatively short period.

The concept of food security dynamics refers to this temporal dimension and encompasses three key elements: long-term trends (is food security improving or deteriorating over time?), volatility (how much does food security fluctuate from year to year?), and structural breaks (are there sudden and persistent changes caused by major events such as the 2007-2008 global food price crisis or the COVID-19 pandemic?) (Barrett, 2010; Headey & Fan, 2010).

Most existing studies of food security in South Asia adopt a cross-sectional perspective, measuring food security at a single point in time and comparing countries accordingly. Relatively few studies have explicitly examined the dynamics of national food security over an extended period. Addressing this gap is one of the principal objectives of the present study, which employs time-series methods specifically designed to capture long-term trends, volatility, and structural changes over time.

2.5. Measurement of Food Security: Indicators and Composite Indices

Measuring a multidimensional concept such as food security is inherently challenging. Over the past several decades, researchers and international organizations have developed a wide range of indicators and composite indices, each capturing different aspects of the concept. Understanding the strengths and limitations of these measurement approaches is essential for justifying the methodological choices adopted in this study.

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Dimensions and Indicators of Food Security

Each of the four classical pillars of food security, availability, access, utilization, and stability, can be measured using a variety of indicators. Food availability is typically assessed through measures such as food production, crop yield per hectare, per capita caloric supply from food balance sheets, and the cereal import dependency ratio. Food access is commonly measured using indicators such as poverty rates, household food expenditure shares, food price indices, and market integration measures. Utilization is generally evaluated through nutritional outcomes, including rates of stunting, wasting, and anemia, as well as dietary diversity scores and access to clean water and sanitation. Stability is measured through year-to-year variability in production and caloric supply, cereal price volatility, and the frequency and severity of food supply shocks (Deitchler *et al*., 2010).

A major systematic review by Rafael Pella (2024) found that most food security measurement studies focus primarily on household-level indicators, particularly calorie intake and dietary diversity. In contrast, national-level indicators, especially those related to stability and utilization, remain relatively underdeveloped. This presents a significant challenge for comparative national-level analysis because much of the available data was not designed for the scale of analysis required by policymakers. The present study addresses this limitation by constructing a national-level composite index using indicators drawn from all six dimensions of its analytical framework.

Household-Level Measures

The most widely used food security measurement tools operate at the household level. The Household Food Insecurity Access Scale (HFIAS) and the Food Insecurity Experience Scale (FIES) are experience-based measures that ask respondents directly about their experiences of food insecurity, including whether they worried about having enough food, reduced meal sizes, or went to bed hungry (Arellano & Bond, 1991; Coates *et al*., 2007; Ballard *et al*., 2011; Ahmad *et al*., 2015). These instruments are highly effective for identifying vulnerable households and targeting social protection and safety-net programs.

However, household-level measures have important limitations when used for national-level comparative analysis. They are sensitive to differences in survey methodology, cultural interpretation of questions, and recall periods, making cross-country comparisons difficult. In addition, they require dedicated household surveys that are not conducted annually in all countries, creating significant gaps for time-series analysis. Most importantly, for the purposes of this study, household-level measures do not adequately capture the broader policy, governance, and structural dimensions of national food security, such as strategic food reserve management, trade policy effectiveness, and the long-term sustainability of food systems.

National-Level and Cross-Country Measures

For comparative national-level analysis, the most widely used composite indicator is the Global Food Security Index (GFSI), published annually by Economist Impact (formerly the Economist Intelligence Unit). The GFSI evaluates countries across four broad dimensions: affordability, availability, quality and safety, using a weighted combination of approximately 68 indicators drawn from international data sources (Economist Impact, 2022). The index currently covers more than 113 countries and facilitates direct cross-country comparison.

Another widely cited measure is the Global Hunger Index (GHI), published annually by Concern Worldwide and Welthungerhilfe. The GHI combines four indicators, undernourishment, child wasting, child stunting, and child mortality, into a composite score intended to capture multiple dimensions of hunger. Like GFSI, it provides a useful basis for international comparison and trend analysis.

Although both indices are valuable, they also have well-documented limitations. The GFSI employs a fixed weighting scheme that may not adequately reflect the varying importance of indicators across different country contexts, while its treatment of the stability dimension remains less developed than its affordability and availability components (FAO,2020). GHI, meanwhile, relies entirely on child and nutrition-related indicators, meaning that it captures food security largely through the lens of nutritional outcomes rather than

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overall national food system performance. Critically, neither index explicitly incorporates agency, defined as a government's capacity to formulate and implement autonomous food policies, or sustainability, referring to the long-term viability of agricultural systems, as formal analytical dimensions. Consequently, while the present study uses GHI scores for external validation, it develops an independent Food Security Index capable of capturing the full six-dimensional framework.

Methodologies for Constructing Composite Food Security Indices

Constructing a composite index such as a National Food Security Index requires a series of methodological decisions, each of which can significantly influence the results. The first major decision concerns normalization, that is, how to make indicators measured in different units, such as tons of wheat, percentages of population, or millimeters of rainfall, directly comparable. Two common methods are z-score normalization, which standardizes indicators around their mean values and standard deviations, and min-max normalization, which rescales indicators to a range between zero and one. Both methods have advantages: z-score normalization preserves the relative distribution of values across countries, whereas min-max normalization is often more intuitive for index construction (Nardo *et al*., 2005).

The second key methodological issue is weighing or determining the relative importance assigned to each indicator. The simplest approach is equal weighting, which assumes that all indicators contribute equally to food security. However, this assumption may not be justified when indicators differ substantially in relevance or data quality. More advanced approaches, such as Principal Component Analysis (PCA) and Factor Analysis, derive weights from the statistical structure of the data itself, assigning greater importance to indicators that explain a larger share of the variation in food security outcomes (Nicoletti *et al*., 2000).

A third methodological consideration concerns the treatment of time. Most existing composite food security indices are cross-sectional, providing only a snapshot of food security for a single year and offering little insight into how conditions evolve over time. The present study addresses this limitation by constructing a time-series composite index covering the period from 2000 to 2025. This approach enables the explicit analysis of long-term trends, volatility, and structural breaks, representing a methodological contribution that remains largely absent from the existing South Asian food security literature.

3. Econometric and Modelling Approaches to Food Security Dynamics

Constructing a composite food security index is only the first step in understanding national food security performance. To examine how food security evolves over time, identify its underlying drivers, and compare trajectories across countries, formal statistical and econometric techniques are required. This section reviews the principal modelling approaches used in the literature and explains why the combination of methods adopted in this study is particularly appropriate for addressing the research objectives.

3.1. Time Series and Panel Approaches

Time series econometric models are specifically designed to analyze changes in a variable over time and to estimate the relationships between that variable and its determinants across multiple periods. Among the most widely used approaches in economic research are the Autoregressive Distributed Lag (ARDL) model and its nonlinear extension, the Nonlinear Autoregressive Distributed Lag (NARDL) model. These techniques are frequently employed to investigate both short-run and long-run relationships between variables, such as the links between food prices and food security or between agricultural productivity and national food availability (Pesaran *et al*., 2001).

The ARDL framework is particularly suitable for the present study because it can accommodate variables with different orders of integration, allowing both stationary and non-stationary series to be analyzed within a unified framework. Moreover, it enables the simultaneous estimation of short-run dynamics and long-run equilibrium relationships, making it highly effective for analyzing the evolution of food security over time.

Vector Autoregression (VAR) and Structural Vector Autoregression (SVAR) models provide another important set of tools for studying dynamic interactions among multiple variables. For example, climate

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shock may reduce agricultural production, which in turn influences food prices and ultimately affects food access and availability. VAR and SVAR models are well suited to capturing these complex interdependencies because they allow multiple variables to interact simultaneously over time (Sims, 1980).

Closely related is the Vector Error Correction Model (VECM), which is designed to capture long-run equilibrium relationships among integrated variables while modelling short-run adjustments toward that equilibrium. VECM is therefore particularly valuable for analyzing structural changes and long-term trends in national food security across decades.

3.2. Volatility and Risk Modelling

One of the most important dimensions of food security, and one that conventional time series models often fail to capture adequately, is volatility. Food security is not only defined by its average level but also by the extent to which it fluctuates over time. Periods characterized by global commodity price spikes, climate shocks, or geopolitical disruptions often experience much greater instability than relatively stable periods. From a policy perspective, this distinction is critical because a country may exhibit an acceptable average level of food security while simultaneously facing severe year-to-year fluctuations that complicate planning and social protection efforts.

To model this changing variability, researchers increasingly employ Generalized Autoregressive Conditional Heteroscedasticity (GARCH) models. Originally developed for financial market analysis, GARCH models have been widely adapted for studies of food price volatility and food security because they explicitly account for time-varying variance and the clustering of high-volatility periods (Engle, 1982; Bollerslev, 1986).

A recent study by Kousar *et al*. (2024) applied multivariate GARCH models to food security indices for South Asian countries and found significant evidence of volatility clustering and spillover effects among Pakistan, India, and Bangladesh. These findings highlight the importance of incorporating volatility-sensitive analytical techniques when studying regional food security dynamics. Building on this literature, the present study employs GARCH-type models to analyze the volatility dimension of national food security across the three countries during the post-globalization period.

3.3. Composite Indices with Advanced Weighting and Dynamic Properties

A growing body of literature integrates composite index construction with dynamic econometric analysis. Rather than treating food security indices as static measures, these studies construct multidimensional national food security indices and then apply time series methods to examine how they evolve over time, identify the factors driving those changes, and assess whether countries are converging toward or diverging from similar levels of food security.

This integrated methodological approach forms the foundation of the present study. By combining advanced index construction techniques with dynamic econometric modelling, the analysis moves beyond simple cross-sectional comparisons and provides a deeper understanding of long-term national food security trajectories and their underlying determinants.

3.4. Machine Learning and Systems Approaches

In recent years, machine learning techniques have increasingly been applied to food security analysis. Methods such as Random Forests, XGBoost, and Neural Networks have been used to predict the onset of food crises, classify levels of food insecurity within early warning systems, and identify the most influential drivers of food insecurity from large and multidimensional datasets (Martini *et al*., 2022). These approaches are especially valuable for predictive tasks where the number of potential explanatory variables is large and the relationships among them are highly nonlinear.

However, machine learning methods are less well suited to the primary objectives of the present study, which include constructing a theoretically grounded composite index, analyzing long-run trends and dynamics, and

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generating policy-relevant comparative insights. The principal strength of machine learning lies in prediction rather than causal explanation or structural interpretation.

For this reason, the study relies primarily on a classical econometric framework that combines PCA-based weighted index construction, ARDL/VECM time series modelling, and GARCH volatility analysis. This methodological combination is better aligned with the objective of producing transparent, interpretable, and policy-relevant findings for a comparative assessment of national food security across Pakistan, India, and Bangladesh.

4. Food Security in South Asia: Regional Evidence

South Asia presents a unique and complex food security challenge. Despite possessing enormous agricultural potential, fertile river deltas, extensive irrigation systems, and a highly experienced farming population, the region continues to host some of the largest food-insecure populations in the world. Understanding this regional context is essential for interpreting the country-specific findings of the present study and for placing national food security trends within a broader comparative framework.

4.1. Structural Drivers of Food Insecurity in South Asia

Several structural characteristics of South Asia's geography, demography, and economic development have shaped the food security outcomes of Pakistan, India, and Bangladesh. Population pressure remains one of the most significant factors. With a combined population approaching 1.9 billion and among the highest population densities globally, the region has very limited scope for expanding agricultural land. Consequently, food security must increasingly be achieved through improvements in productivity and yield intensification on existing farmland (FAO, 2023). This reality places immense pressure on irrigation infrastructure, soil quality, and water resources, challenges that are becoming even more acute under climate change.

Dependence on irrigation is another major structural vulnerability. Pakistan's agricultural production relies almost entirely on the Indus River irrigation system, the largest contiguous irrigation network in the world. Any disruption to this system, whether caused by upstream water disputes with India, glacial retreat, or failures in canal infrastructure, can have immediate and severe consequences for national food production (Qureshi *et al*., 2009). Similarly, India's Green Revolution heartland in Punjab and Haryana depends heavily on groundwater irrigation, where aquifer levels are declining at alarming rates. In Bangladesh, Boro rice cultivation, which accounts for more than half of annual rice production, depends largely on tube-well irrigation, making it highly sensitive to both the quality and availability of groundwater resources.

At the regional level, several institutional efforts have sought to strengthen collective food security mechanisms. The SAARC Food Bank, established in 2007, was intended to provide a shared regional food reserve that member countries could access during emergencies. In practice, however, the initiative has remained largely ineffective due to persistent political tensions, particularly between Pakistan and India, which have hindered meaningful activation and cooperation. Likewise, the South Asia Food and Nutrition Security Initiative (SAFANSI), supported by the World Bank, has promoted regional research collaboration and policy dialogue but has had only limited operational impact. Moreover, South Asia remains one of the least economically integrated regions in the world. High trade barriers restrict the movement of food commodities across borders, preventing surpluses in one country from efficiently addressing shortages in another.

4.2. Climate Change, Shocks, and Vulnerability

Climate change has already emerged as one of the most influential drivers of food security dynamics in South Asia, and its impacts are expected to intensify significantly over the coming decades. All three countries examined in this study face serious but distinct climate-related risks.

Pakistan is perhaps the most acutely vulnerable. It ranks among the ten countries most affected by climate-related disasters globally, and the catastrophic floods of 2010 and 2022, which submerged approximately

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one-fifth and one-third of the country, respectively, caused billions of dollars in agricultural losses and displaced millions of farming households (National Disaster Management Authority (NDMA), 2022).

India faces increasing risks from heat stress affecting wheat and rice production, increasingly erratic monsoon patterns, and the accelerating retreat of Himalayan glaciers that supply water to the river systems upon which northern Indian agriculture depends (Lobell *et al*., 2011; Kumar *et al*., 2014; Lentz *et al*., 2021). Bangladesh, meanwhile, is highly vulnerable to cyclone intensification, seasonal flooding, and the gradual inundation of coastal farmland due to rising sea levels. Some estimates suggest that up to 17 percent of Bangladesh's land area could be permanently flooded by 2050 (Intergovernmental Panel on Climate Change (IPCC), 2022).

Importantly, climate shocks do not occur in isolation. They interact with pre-existing economic and structural vulnerabilities and can create long-lasting disruptions to national food security trajectories. The 2022 floods in Pakistan, for example, not only reduced agricultural output during that year but also damaged irrigation infrastructure, depleted household savings and productive assets, and triggered a surge in food price inflation that continued through 2023 and 2024. Understanding the interaction between climate shocks and food security dynamics, particularly how these shocks influence both the level and volatility of food security, forms a central component of the econometric analysis undertaken in this study.

4.3. Regional Policy Responses and Cooperation

Despite the common nature of many food security challenges across South Asia, regional policy cooperation has remained limited. Most food security strategies continue to be designed and implemented at the national level, with relatively little cross-border coordination or institutional collaboration.

A notable example is India's unilateral decision to impose wheat export bans during the 2007–2008 food price crisis and again in 2022. These measures had immediate adverse effects on neighboring countries, particularly Pakistan and Bangladesh, both of which were seeking wheat imports during these periods. However, no effective regional mechanism existed to coordinate policy responses or mitigate the resulting supply disruptions (Mitra & Josling, 2009).

The limited degree of regional cooperation represents not only a practical policy challenge but also an important gap in academic literature. Very few studies have examined the food security dynamics of Pakistan, India, and Bangladesh simultaneously within a unified analytical framework capable of generating coordinated regional policy insights. Most comparative research focuses either on pairs of countries or relies on highly aggregated South Asian averages that conceal important national differences.

The present study contributes directly to addressing this gap by conducting a rigorous, parallel, and methodologically consistent comparative analysis of all three countries. By employing a common conceptual framework and harmonized time-series data, the study seeks to generate evidence that can inform both national and regional food security policymaking.

5. Country-Specific Literature: Pakistan, India, and Bangladesh

Each of the three countries examined in this study has followed a distinct food security trajectory shaped by its unique geography, political economy, agricultural resource base, and policy choices. This section reviews the country-specific literature on Pakistan, India, and Bangladesh, focusing on their food security experiences, institutional responses, key determinants, and emerging challenges. The discussion provides the contextual foundation for the comparative analysis presented in subsequent chapters.

5.1. National Food Security in Pakistan

Pakistan's food security experience can largely be described as a story of unrealized agricultural potential. The country possesses one of the world's largest contiguous river-based irrigation systems, fertile agricultural plains in Punjab and Sindh, and a substantial rural labor force. It was also among the earliest adopters of Green Revolution technologies during the 1960s, achieving near self-sufficiency in staple food production by the early 1970s. Despite these advantages, however, Pakistan continues to face persistent food

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security challenges. According to the 2023 Global Hunger Index (GHI), the country ranked 102nd out of 125 countries, with its food system increasingly strained by water scarcity, macroeconomic instability, and recurrent climate-related shocks.

Pakistan's food security policy has historically been shaped by the need to balance two competing objectives: maintaining affordable food prices for urban consumers while ensuring sufficiently attractive producer prices to encourage agricultural production. This balance has largely been managed through government procurement of wheat at support prices, strategic storage in public warehouses, and distribution through subsidized channels (Dorosh & Salam, 2008). Since the adoption of the 18th Constitutional Amendment in 2010, responsibility for agriculture and food security has shifted from the federal government to the provincial governments. While this devolution has created opportunities for provincial innovation and localized policy responses, it has also introduced new challenges for national food security governance.

Empirical evidence suggests that Pakistan's food security is highly sensitive to fluctuations in domestic wheat prices, agricultural terms of trade, rural poverty, and climatic variability. The devastating floods of 2022, which affected crops over more than 3.5 million hectares, highlighted the vulnerability of the country's food system by disrupting agricultural production, damaging infrastructure, and exacerbating food price inflation. Although the literature on Pakistan's food security is extensive, it remains fragmented. Few studies have systematically examined long-term national food security trends using consistent methodologies, and none have conducted such an analysis within a rigorous comparative framework alongside India and Bangladesh.

5.2. National Food Security in India

India's food security experience is characterized by a notable paradox. The country is one of the world's largest producers and exporters of cereals, maintains the largest publicly managed grain stock system globally, and routinely exports millions of tons of food grains. Yet, despite these achievements, India continues to face serious hunger and malnutrition challenges. The 2023 Global Hunger Index ranked India 111th out of 125 countries, and the FAO estimates that more than 195 million people remain undernourished (FAO, 202).

India has developed the most comprehensive food security policy architecture in South Asia. The enactment of the National Food Security Act (NFSA) in 2013 established a legal entitlement to subsidized food grains for approximately 800 million people through the Targeted Public Distribution System (TPDS), administered by the Food Corporation of India (FCI). Under this system, wheat and rice are procured from farmers at government-declared minimum support prices and distributed to eligible households at highly subsidized rates. The effectiveness of this model has generated extensive scholarly debate. Proponents argue that it has prevented widespread food deprivation and strengthened state accountability for food provision, whereas critics highlight significant leakages, substantial fiscal costs, and limited nutritional outcomes relative to public expenditure (Gulati *et al*., 2020).

The dynamics of India's food security since 2000 have been influenced by three interrelated factors: long-term trends in agricultural productivity, climate-induced production variability, and the policy environment encompassing export controls, input subsidies, and the TPDS. Time-series studies indicate that while national food availability has remained relatively stable at high levels, the access and utilization dimensions of food security continue to exhibit significant spatial disparities and temporal volatility (Kumar *et al*., 2014; Pingali *et al*., 2019).

5.3. National Food Security in Bangladesh

Bangladesh's food security trajectory represents one of the most remarkable development successes of the past half century. At independence in 1971, the country emerged from a devastating liberation war with a severely damaged economy, widespread food shortages, and an agricultural sector in disarray. Frequently characterized at the time as a "basket case," Bangladesh appeared to have limited prospects for achieving food self-sufficiency. However, by the early 2000s the country had attained self-sufficiency in rice

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production, and by 2023 it ranked 81st in the Global Hunger Index with a "moderate" hunger score, outperforming its South Asian neighbors.

This transformation has been driven largely by sustained investments in agricultural research and technological innovation, particularly through the development and widespread adoption of high-yielding rice varieties by the Bangladesh Rice Research Institute (BRRI) and the International Rice Research Institute (IRRI). The expansion of Boro (winter irrigated) rice cultivation effectively introduced a third annual rice crop, substantially increasing national production. Furthermore, the development of flood-tolerant rice varieties through collaboration with IRRI significantly reduced crop losses associated with seasonal flooding (Mackill *et al*., 2012).

Despite these achievements, Bangladesh's food system remains exposed to several structural vulnerabilities. The country relies heavily on wheat imports, making its food access dimension particularly sensitive to global commodity price fluctuations and supply chain disruptions. The Russia-Ukraine conflict in 2022, for example, disrupted international wheat markets, increased import costs, and contributed to substantial domestic food price inflation. In the longer term, climate change poses perhaps the greatest challenge to Bangladesh's food security. Rising sea levels, increased cyclone intensity, and the progressive salinization of coastal agricultural land threaten to undermine the country's hard-earned gains in agricultural productivity and food self-sufficiency.

5.4. Comparative Insights across Pakistan, India, and Bangladesh

Comparative studies examining food security across Pakistan, India, and Bangladesh remain surprisingly limited, despite the countries shared historical, geographical, and developmental characteristics. Most existing comparative analyses focus on pairs of countries, commonly India and Bangladesh or India and Pakistan, while broader South Asian studies often rely on highly aggregated regional averages that obscure important country-level differences. The relatively few studies that examine all three countries together are generally descriptive, presenting side-by-side statistics without employing a formal analytical or econometric framework to assess differences in food security dynamics.

A recent contribution by Kousar *et al*. (2024) represents an important exception. Using a multivariate GARCH framework, the study explicitly compares food security volatility across South Asian countries. However, its focus is limited to volatility, and the analysis covers only a relatively short time horizon. To date, no study has developed a multidimensional national food security index for Pakistan, India, and Bangladesh simultaneously, tracked its evolution over the entire post-2000 period, analyzed its determinants using panel econometric techniques, and benchmarked the results against Global Hunger Index (GHI) scores. Addressing this gap constitutes one of the principal contributions of the present study.

The available comparative literature nevertheless reveals several common patterns. Since 2000, all three countries have improved the availability dimension of food security, largely driven by gains in agricultural productivity, although the pace of improvement has been slower in Pakistan and India than in Bangladesh. Progress in food access has been more uneven. Bangladesh has achieved faster reductions in poverty and greater improvements in access to food, whereas Pakistan continues to face persistent challenges, particularly in rural areas and among female-headed households. With respect to stability, all three countries have become increasingly vulnerable to external food price shocks and climate-related production volatility during the post-globalization period (FAO, 2023). These shared trends, coupled with important structural differences, underscore the value of adopting a common analytical framework for comparative assessment and policy learning across the three countries.

6. Identified Research Gaps

The preceding review of the literature reveals a clear pattern: although there is a substantial body of research on food security in South Asia, several important conceptual, methodological, and policy-related gaps remain. Existing studies have generated valuable insights into specific dimensions of food security, yet they often address these dimensions in isolation and lack an integrated comparative perspective. This section

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synthesizes these shortcomings and identifies three interconnected research gaps that the present study is designed to address.

6.1. Gaps in Measurement and Index Construction

The first major gap concerns the measurement of national food security. As discussed throughout this chapter, the existing literature is dominated by household-level assessment tools, such as the Household Food Insecurity Access Scale (HFIAS), the Food Insecurity Experience Scale (FIES), and dietary diversity indicators. While these instruments are highly effective for assessing household vulnerability, they are not designed for national-level comparative analysis.

At the national level, the two most widely used composite measures are the Global Food Security Index (GFSI) and the Global Hunger Index (GHI). However, both indices have important limitations. The GFSI relies on predetermined and largely subjective weighting schemes, while the GHI focuses primarily on child nutritional outcomes rather than overall national food system performance. Moreover, neither index explicitly incorporates agency defined as the capacity of governments to pursue autonomous and effective food policies or sustainability, which reflects the long-term viability of agricultural and food systems.

For Pakistan, India, and Bangladesh, no existing study has developed a methodologically rigorous national food security index covering the full period from 2000 to 2025 using statistically derived weighting techniques, such as Principal Component Analysis (PCA) or entropy methods, within a comprehensive six-dimensional framework encompassing availability, access, utilization, stability, agency, and sustainability. This methodological gap has important practical implications. Without such a tool, policymakers lack a robust mechanism to monitor changes in national food security over time, identify strengths and weaknesses across different dimensions, and benchmark national performance against comparable countries using a consistent analytical framework.

6.2. Gaps in Dynamic and Comparative Analysis

The second major gap relates to the dynamic and comparative analysis of food security. Much of the existing South Asian literature adopts a cross-sectional approach, examining food security at a single point in time or comparing countries using static indicators. Such studies rarely investigate how food security evolves over time, what factors drive these changes, or whether the trajectories of Pakistan, India, and Bangladesh are converging or diverging.

The post-2000 period, referred to in this study as the post-globalization era, has been characterized by profound structural transformations affecting regional food systems. These include the completion of trade liberalization processes, the global food price crises of 2007–2008 and 2010–2011, the COVID-19 pandemic (2020–2022) and its aftermath, the Russia–Ukraine conflict beginning in 2022, and the accelerating impacts of climate change. Collectively, these events have generated structural breaks and heightened volatility in food security trends that cannot be adequately captured using conventional cross-sectional methods.

Addressing these dynamics requires the application of advanced time-series and panel econometric techniques, including ARDL/NARDL, VECM, and GARCH models, which can analyze long-run relationships, short-run adjustments, and volatility patterns. However, these approaches have been employed in only a limited number of South Asian food security studies and, to date, have not been applied comprehensively across Pakistan, India, and Bangladesh within a unified comparative framework.

6.3. Gaps in Policy-Oriented Comparative Research

The third major gap exists at the policy level. Even where rigorous empirical analyses of national food security are available, they are generally country-specific and do not readily translate into comparative policy lessons. Consequently, policymakers have limited evidence to guide cross-country learning. For example, a policymaker in Bangladesh seeking to understand the implications of Pakistan's wheat reserve management system, or the trade-offs associated with India's Public Distribution System, has relatively little systematic and comparable empirical evidence on which to draw.

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This limitation is significant because many of the most effective food security interventions emerge through the adaptation of successful policies and institutional arrangements from comparable contexts. The absence of a common analytical framework for evaluating food security performance across Pakistan, India, and Bangladesh means that cross-country policy learning remains largely informal and unsystematic.

The present study addresses this gap by employing a unified conceptual framework, a consistent multidimensional food security index, and harmonized time-series datasets across all three countries. By combining rigorous comparative analysis with policy-oriented interpretation, the study aims to generate evidence that not only advances academic understanding but also supports informed, evidence-based policymaking and regional learning in South Asia.

7. Conclusion

The literature reviewed in this chapter demonstrates that food security has evolved from a narrow concern with aggregate food production to a multidimensional concept encompassing access, utilization, stability, agency, and sustainability. Contemporary scholarship increasingly recognizes that ensuring food security requires not only sufficient food supplies but also resilient institutions, effective governance, inclusive policies, and environmentally sustainable production systems.

A key insight emerging from the review is that food security is inherently dynamic. It changes over time in response to demographic pressures, market fluctuations, climate variability, technological change, and policy interventions. Events such as the global food price crisis, the COVID-19 pandemic, and recent climate-related disasters have highlighted the vulnerability of national food systems and the need for analytical frameworks capable of capturing long-term trends as well as short-term disruptions.

The review also reveals an important imbalance in existing literature. Much of the available research remains focused on household-level indicators and cross-sectional assessments, while comparatively little attention has been devoted to the long-run evolution of national food security or to systematic comparisons across countries. For South Asia in particular, studies that examine Pakistan, India, and Bangladesh within a common conceptual and methodological framework are limited, despite the shared historical, geographical, and developmental characteristics of these countries.

Another significant finding is the inadequacy of existing national food security measures for capturing the full complexity of modern food systems. Widely used indices such as the Global Food Security Index and the Global Hunger Index provide valuable benchmarks but do not fully account for dimensions such as institutional capacity, policy autonomy, and environmental sustainability. Similarly, while recent advances in econometric modelling and machine learning have expanded the analytical toolkit available to researchers, there remains a need for approaches that combine rigorous statistical analysis with clear policy relevance and interpretability.

The evidence from Pakistan, India, and Bangladesh further illustrates that improvements in food availability alone are insufficient to guarantee broader food and nutrition security. Persistent challenges related to poverty, dietary quality, climate vulnerability, water scarcity, and governance continue to shape national outcomes. At the same time, differences in policy choices and institutional arrangements across the three countries offer valuable opportunities for comparative learning and regional cooperation.

Overall, the literature points to the need for an integrated, multidimensional, and longitudinal approach to national food security analysis. Such an approach should combine diverse indicators into a comprehensive framework, account for temporal dynamics and structural change, and facilitate meaningful cross-country comparison. By addressing these gaps, future research can generate stronger empirical evidence to support resilient, inclusive, and sustainable food security policies across South Asia and contribute to the broader objective of achieving Zero Hunger under the Sustainable Development Goals.

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References

Ahmad, M., Iqbal, M., & Farooq, U. (2015). Food security and its constraining factors in South Asia: challenges and opportunities. PIDE Working paper no. 10. Pakistan Institute of Development Economics, Islamabad, Pakistan. https://file.pide.org.pk/pdf/Climate_Change_10.pdf

Arellano, M., & Bond, S. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *The Review of Economic Studies*, *58*(2), 277–297. https://doi.org/10.2307/2297968

Ballard, T., Coates, J., Swindale, A., & Deitchler, M. (2011). Household hunger scale: indicator definition and measurement guide. *Washington, DC: Food and nutrition technical assistance II project, FHI*, *360*, 23. https://www.fantaproject.org/sites/default/files/resources/HHS-Indicator-Guide-Aug2011.pdf

Barrett, C. B. (2010). Measuring food insecurity. *Science*, *327*(5967), 825-828. https://doi.org/10.1126/science.1182768

Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, *31*(3), 307-327. https://doi.org/10.1016/0304-4076(86)90063-1

Chambers, R., & Conway, G. (1991). Sustainable rural livelihoods: Practical concepts for the 21st century. IDS Discussion Paper 296. Institute of Development Studies. https://www.ids.ac.uk/files/Dp296.pdf

Clapp, J. (2017). Food self-sufficiency: Making sense of it, and when it makes sense. *Food policy*, *66*, 88-96. https://doi.org/10.1016/j.foodpol.2016.12.001

Coates, J., Swindale, A., & Bilinsky, P. (2007). Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide: version 3. https://www.fao.org/fileadmin/user_upload/eufao-fsi4dm/doc-training/hfias.pdf

Deitchler, M., Ballard, T., Swindale, A., & Coates, J. (2010). Validation of a measure of household hunger for cross-cultural use. *Washington, DC: Food and Nurtrition Technical Assistance II Project (FANTA-2), Acedemy for Educational Development*, 2009-2017. https://www.fantaproject.org/sites/default/files/resources/HHS_Validation_Report_May2010_0.pdf?__cf_chl_f_tk=splkmTB8QYS3s5.aDAcdz7nTuhg4gcdkQHHMdJoAsbg-1783106750-1.0.1.1-UB1aRNWJeU.KOnmLGGvlX9hpQ1B4.SOkw.4IxRd0q14

Dorosh, P., & Salam, A. (2008). Wheat markets and price stabilisation in Pakistan: An analysis of policy options. *The Pakistan Development Review*, 71-87. https://www.jstor.org/stable/41260818

Dreyer-Gibney, K., Coughlan, P., Coghlan, D., Wu, S. H., Bello-Dambatta, A., Dallison, R., ... & Williams, P. (2024). Responding to the UN sustainability goals in transdisciplinary partnership through network action learning. *Environment, Development and Sustainability*, *26*(12), 31757-31788. https://doi.org/10.1007/s10668-024-04664-9

Economist Impact. (2022). *Global Food Security Index 2022*. https://insights.economistenterprise.com/sustainability/project/food-security-index/

Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica: Journal of the Econometric Society*, 987-1007. https://doi.org/10.2307/1912773

FAO. (2008). *Climate Change: Implications for Food Safety*. Food and Agriculture Organization https://www.fao.org/4/i0195e/i0195e00.pdf

FAO. (2020). Climate change: Unpacking the burden on food safety. Food and Agriculture Organization of the United Nations: Rome, Italy. https://openknowledge.fao.org/items/b9c3ede0-c193-4329-b341-5c2c1c52b43e

FAO, IFAD, UNICEF, WFP, & WHO. (2023). *The state of food security and nutrition in the world 2023: Urbanization, agrifood systems transformation and healthy diets across the rural–urban continuum*. Food and Agriculture Organization of the United Nations: Rome, Italy. https://doi.org/10.4060/cc3017en

Gulati, A., Jain, S., & Satija, N. (2014). Rising farm wages in India—The 'pull'and 'push'factors. *Journal of Land and Rural Studies*, *2*(2), 261-286. https://doi.org/10.1177/2321024914534045

Headey, D., & Fan, S. (2010). *Reflections on the global food crisis: How did it happen? How has it hurt? And how can we prevent the next one?* Intl Food Policy Res Inst, Research Monograph 165. https://cgspace.cgiar.org/server/api/core/bitstreams/ae207582-8ed2-4f7c-865b-297c76e970ce/content

HLPE. (2017). *Nutrition and food systems*. High Level Panel of Experts on Food Security and Nutrition. https://openknowledge.fao.org/server/api/core/bitstreams/4ac1286e-eef3-4f1d-b5bd-d92f5d1ce738/content

IFPRI. (2014). 2014 Global Hunger Index: The challenge of hidden hunger. IFPRI, Welthungerhilfe, and Concern Worldwide. https://www.welthungerhilfe.de/fileadmin/pictures/publications/en/studies_analysis/2014_ghi_challenge_of_hidden_hunger_en.pdf

Immerzeel, W. W., Van Beek, L. P., & Bierkens, M. F. (2010). Climate change will affect the Asian water towers. *Science*, *328*(5984), 1382-1385. https://doi.org/10.1126/science.1183188

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Kousar, S., Ameer, A., Nasir, A., Afzal, M., & Abbas, S. (2024). Comparative analysis to assess food security in South Asian nations: An application of multivariate GARCH model. Environment, Development and Sustainability. https://doi.org/10.1007/s10668-024-05737-5

Kumar, S. N., Aggarwal, P. K., Rani, D. S., Saxena, R., Chauhan, N., & Jain, S. (2014). Vulnerability of wheat production to climate change in India. *Climate Research*, *59*, 173-187. https://doi.org/10.1016/B978-0-12-821316-2.00014-5

Lentz, E., Bageant, E., & Narayanan, S. (2021). Empowerment and nutrition in Niger: insights from the Women's Empowerment in Nutrition grid. *Food Security*, *13*(5), 1227-1244. http://doi.org/10.1007/s12571-021-01155-x

Lobell, D. B., Schlenker, W., & Costa-Roberts, J. (2011). Climate trends and global crop production since 1980. *Science*, *333*(6042), 616-620. https://doi.org/10.1126/science.1204531

Mackill, D. J., Ismail, A. M., Singh, U. S., Labios, R. V., & Paris, T. R. (2012). Development and rapid adoption of submergence-tolerant (Sub1) rice varieties. *Advances in Agronomy*, *115*, 299-352. https://doi.org/10.1016/B978-0-12-394276-0.00006-8

Malthus, T. R. (1798). *An essay on the principle of population*. J. Johnson. London, UK.

Martini, G., Bequet, R., Costa, H., Egger, M., Fraiberger, S., Lambiotte, R., Pentland, A., Currier, K., & Cuevas, P. C. (2022). Machine learning can guide food security efforts when primary data are not available. Nature Food, 3(9), 716-728. https://doi.org/10.1038/s43016-022-00587-8

Mitra, S., & Josling, T. (2009). *Agricultural export restrictions: Welfare implications and trade disciplines*. Position Paper International Food and Agricultural Trade Policy Council*, IPC*. Washington DC., USA.

Nardo, M., Saisana, M., Saltelli, A., Tarantola, S., Hoffman, A., & Giovannini, E. (2005). *Handbook on constructing composite indicators: Methodology and user guide*. OECD Statistics Working Papers, 2005/3, OECD Publishing. https://doi.org/10.1787/9789264043466-en

National Disaster Management Authority. (2022). *NDMA floods 2022 daily situation report No. 137*. Government of Pakistan. https://reliefweb.int/report/pakistan/ndma-monsoon-2022-daily-situation-report-no-137-dated-28th-oct-2022

Nicoletti, G., Scarpetta, S., & Boylaud, O. (2000). *Summary indicators of product market regulation with an extension to employment protection legislation*. OECD Economics Department Working Papers, No. 226. https://www.oecd.org/content/dam/oecd/en/publications/reports/2000/04/summary-indicators-of-product-market-regulation-with-an-extension-to-employment-protection-legislation_g17a13f9/215182844604.pdf

Pakistan Bureau of Statistics. (2023). *Pakistan Demographic Survey 2023*. Government of Pakistan, Islamabad, Pakistan.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, *16*(3), 289-326. https://www.jstor.org/stable/2678547

Pingali, P. L. (2012). Green revolution: impacts, limits, and the path ahead. *Proceedings of the National Academy of Sciences*, *109*(31), 12302-12308. https://doi.org/10.1073/pnas.0912953109

Pingali, P., Mittra, B., & Rahman, A. (2019). The bumpy road from food to nutrition security - Slow evolution of India's food policy. *Global Food Security*, *23*, 77-84. https://doi.org/10.1016/j.gfs.2017.05.002

Prakash, A., Conde, C., Ayanlade, A., Kerr, R. B., Boyd, E., Caretta, M. A., ... & Tirado-von der Pahl, M. (2022). Cross-chapter box gender| gender, climate justice and transformative pathways. *Climate Change*, 2700-2704.

Qureshi, A. S., McCornick, P. G., Sarwar, A., & Sharma, B. R. (2009). Challenges and prospects of sustainable groundwater management in the Indus Basin, Pakistan. *Water Resources Management*, *24*(8), 1551-1569. https://doi.org/10.1007/s11269-009-9513-3

Sen, A. (1983). *Poverty and famines: An essay on entitlement and deprivation*. Oxford University Press. https://doi.org/10.1093/0198284632.001.0001

Sims, C. A. (1980). Macroeconomics and reality. Econometrica, 48(1), 1-48. https://doi.org/10.2307/1912017

United Nations. (2015). Transforming our world: The 2030 agenda for sustainable development. United Nations. https://www.unfpa.org/resources/transforming-our-world-2030-agenda-sustainable-development

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CHAPTER 20

Food Waste among Young Consumers in Developing Countries: Trends, Determinants, and Sustainability Challenges

Hafiza Javeria Shehzadi[1], Muhammad Umer Farrukh[1,*], Omar Abdullah Alkhateeb[2], Shazia Kousar[4], Sana Butt[1], Muhammad Umair Ashraf [3] & Ayesha Batool[1]
[1]Department of Economics, Faculty of Administrative and Management Sciences, Government College Women University Sialkot, Pakistan.
[2]Department of Agribusiness and Consumer Sciences, College of Agriculture & Food Sciences, King Faisal University, Al-Ahsa, Saudi Arabia
[3]Department of Sociology, Government College Women University Sialkot.
[4] Department of English Linguistics, University of Narowal, Pakistan
Corresponding authors' email: umarfarrukh@outlook.com

Abstract

Food waste has become a critical global challenge with profound economic, environmental, and social implications, undermining efforts to achieve sustainable development and food security. In recent years, increasing attention has been directed toward food waste generated by young consumers, particularly university students, whose food consumption patterns, lifestyles, and purchasing behaviors significantly influence waste generation. This chapter provides a comprehensive review of the literature on food waste among young consumers in developing countries, with a special emphasis on institutional and university settings. It synthesizes the conceptual and theoretical foundations of food waste by drawing on the economic theory of consumer behavior, the Theory of Planned Behavior, institutional theory, and behavioral economics to explain the complex interplay between individual choices and structural factors. The chapter further examines global and regional evidence on food waste trends, highlighting differences between developed and developing countries and discussing the growing significance of consumption-stage waste in South Asia and Pakistan. Attention is given to the behavioral, socio-demographic, economic, and institutional determinants that shape food waste practices among university students, as well as the methodologies used to measure food waste in educational institutions. The review identifies important research gaps, including the lack of micro-level evidence from Pakistani universities, limited investigation of institutional determinants, and the absence of systematic evaluations of campus-based waste reduction interventions. By integrating theoretical insights and empirical evidence, the chapter develops a conceptual framework that links key determinants to food waste outcomes and establishes a strong foundation for future empirical research and policy interventions aimed at promoting sustainable food consumption and reducing food waste among young consumers in developing countries.

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1. Introduction

Food waste has emerged as one of the most pressing global sustainability challenges, with significant economic, environmental, and social consequences. Despite substantial advances in agricultural productivity and food distribution systems, a considerable proportion of food produced for human consumption is lost or wasted across different stages of the food supply chain, with a large share occurring at the consumption stage (Gustavsson *et al*., 2011). The wastage of edible food not only represents a loss of valuable resources such as land, water, energy, labor, and capital but also contributes to greenhouse gas emissions, environmental degradation, and increasing pressure on already fragile food systems. At a time when millions of people worldwide continue to face food insecurity and malnutrition, reducing food waste has become an essential

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component of achieving the Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger) and SDG 12 (Responsible Consumption and Production).

In recent years, growing scholarly attention has been directed toward food waste generated by young consumers, particularly within higher education institutions. Universities constitute a unique and important setting for food waste research because large numbers of students consume meals daily through cafeterias, hostels, canteens, and campus events. The food consumption behaviors established during university life often shape long-term dietary habits and lifestyle choices, making young adults a critical demographic for promoting sustainable consumption practices (Stancu *et al*., 2016). University students are also exposed to a combination of individual, social, and institutional influences that affect food-related decisions, including limited time for meal planning, changing dietary preferences, peer influence, financial considerations, and the availability of subsidized or institutionally provided meals.

Existing research suggests that food waste among university students is not merely the outcome of individual behavior but rather the result of a complex interaction between behavioral, socio-demographic, economic, and institutional factors. Behavioral characteristics such as inadequate meal planning, impulsive food purchases, over-serving, and a low tendency to utilize leftovers have been identified as important drivers of food waste (Parizeau *et al*., 2015). Similarly, socio-demographic factors, including income level, educational background, living arrangements, and dietary preferences, shape food consumption and disposal patterns. Social norms, peer influences, and personal values further affect attitudes toward food conservation and sustainable practices (Visschers *et al*., 2016). At the institutional level, food service practices such as fixed portion sizes, limited menu flexibility, inconsistent food quality, and pricing strategies can significantly contribute to waste generation in university cafeterias (Whitehair *et al*., 2013).

The literature also emphasizes that awareness of the environmental and ethical implications of food waste does not necessarily translate into waste-reducing behavior. Many students recognize the negative impacts of food waste, yet practical constraints and behavioral tendencies often prevent them from adopting more sustainable consumption practices. This disconnects between knowledge and action has led researchers to increasingly apply interdisciplinary theoretical perspectives, including the economic theory of consumer behavior, the Theory of Planned Behavior (Ajzen, 1991), institutional theory, and behavioral economics, to better understand the motivations and constraints underlying food waste behavior.

Against this background, a comprehensive review of the literature is essential for synthesizing existing knowledge, identifying the key determinants of food waste among young consumers, and highlighting areas where further research is required. Although a substantial body of international literature exists, evidence from developing countries remains comparatively limited, particularly regarding university settings where food waste behavior is shaped by distinct social, cultural, and institutional conditions. In Pakistan, existing studies have largely focused on household food waste and post-harvest losses, while relatively little attention has been devoted to food waste among university students or the role of institutional food service systems in influencing waste generation.

Accordingly, this chapter critically reviews the national and international literature on food waste among young consumers, with a particular emphasis on university and institutional settings in developing countries. It begins by discussing the conceptual and theoretical foundations of food waste and the principal frameworks used to explain food waste behavior. The chapter then reviews global and regional evidence on food waste trends and examines the growing importance of consumption-stage waste in developing countries, particularly Pakistan. This is followed by an analysis of food waste within university and institutional settings and a detailed discussion of the behavioral, socio-demographic, economic, and institutional determinants of food waste. The chapter also reviews existing approaches to measuring food waste and identifies key methodological and empirical gaps in literature. Finally, it develops a conceptual framework that links the major determinants of food waste to expected outcomes and provides the theoretical foundation for the empirical analysis undertaken in the present study.

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2. Conceptual and Theoretical Foundations of Food Waste

Food waste is a complex and multidimensional phenomenon that cannot be adequately explained through a single theoretical perspective. The generation of food waste results from the interaction of economic decision-making, behavioral intentions, social norms, institutional arrangements, and psychological influences. Consequently, understanding food waste behavior, particularly among university students and young consumers, requires an interdisciplinary framework that integrates insights from economics, psychology, sociology, and organizational studies (Thyberg & Tonjes, 2016; Visschers *et al*., 2016). Such an approach helps explain why individuals continue to waste food despite recognizing its economic value, environmental implications, and ethical significance.

The existing literature suggests that food waste in university settings is shaped not only by individual preferences but also by the institutional context within which food choices are made. Consumption decisions are influenced by factors such as food pricing, meal plans, portion sizes, social interactions, time constraints, and campus food service practices. Therefore, theoretical frameworks that account for both individual behavior and structural influences are essential for understanding the determinants of food waste and for designing effective interventions to reduce it.

This section reviews the principal theoretical perspectives that have been widely applied in food waste research. It begins with the economic theory of consumer behavior, which explains food waste from the perspective of rational decision-making and utility maximization. It then examines the Theory of Planned Behavior (TPB), one of the most influential behavioral models for explaining food waste intentions and actions. The discussion subsequently turns to institutional theory, which highlights the role of organizational structures and food service systems in shaping consumption patterns, followed by the behavioral economics perspective, which emphasizes the importance of cognitive biases and heuristics in food-related decision-making. Together, these theoretical frameworks provide an integrated foundation for understanding food waste behavior among young consumers and support the conceptual framework adopted in the present study.

2.1. Economic Theory of Consumer Behavior and Food Waste

The economic theory of consumer behavior posits that individuals make rational choices aimed at maximizing utility while operating within budget constraints (Becker, 1965). Consumers are expected to allocate their resources in ways that provide the greatest level of satisfaction. However, in the context of food consumption, rational decision-making does not necessarily prevent food waste. When food is relatively affordable or readily available, individuals may purchase or serve quantities that exceed their actual needs, resulting in food disposal (Aschemann-Witzel *et al*., 2015).

Within university environments, subsidized cafeteria meals, fixed meal plans, and limited direct financial responsibility can reduce students' perception of the economic value of food. Consequently, the marginal cost of discarding uneaten food appears relatively low, increasing the likelihood of waste. Economic theory also emphasizes concepts such as opportunity cost and diminishing marginal utility. When the effort required to store, preserve, or reuse leftover food exceeds the perceived benefits, individuals may choose to dispose of surplus food instead. Moreover, academic workload and time constraints often encourage students to prioritize convenience over efficient food management (Parizeau *et al*., 2015). From this perspective, food waste occurs because the perceived costs of preventing waste are considered greater than the expected benefits, particularly in environments where food is abundant or subsidized.

2.2. Theory of Planned Behavior (TPB) and Food Waste

The Theory of Planned Behavior (TPB), developed by Ajzen (1991), is one of the most influential frameworks for explaining food waste behavior. TPB proposes that an individual's behavior is primarily determined by behavioral intention, which in turn is influenced by three key constructs: attitude toward the behavior, subjective norms, and perceived behavioral control.

In the context of food waste, students' attitudes toward food conservation, environmental sustainability, and ethical consumption significantly shape their intentions to minimize waste (Stancu *et al*., 2016). However,

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subjective norms, including peer influence, social dining habits, and cultural expectations, may encourage over-serving or excessive food consumption. Likewise, perceived behavioral control plays a crucial role in determining whether individuals can effectively avoid wasting food. Factors such as flexible portion sizes, access to food storage facilities, availability of leftovers, and time management affect students' ability to translate positive intentions into responsible behavior.

Empirical evidence indicates that even when students express a strong commitment to reducing food waste, situational constraints often limit their capacity to act accordingly (Visschers *et al*., 2016). This gap between awareness and actual behavior is a recurring finding in literature and highlights the value of TPB as a framework for understanding the psychological and social processes underlying food waste in university settings.

2.3. Institutional Theory and Organizational Influences

While individual choices are important, food waste in universities cannot be fully understood without considering the institutional environment in which those choices occur. Institutional theory emphasizes the influence of organizational structures, formal rules, social norms, and administrative practices on individual behavior (Scott, 2008; Wang *et al*., 2021). From this perspective, food waste is not solely the result of personal decisions but is also shaped by the design and operation of institutional food systems.

Within universities, factors such as standardized portion sizes, inflexible meal plans, limited menu customization, and inconsistent food quality have been identified as major contributors to food waste (Whitehair *et al*., 2013). When institutional food service practices fail to align with students' preferences and actual consumption needs, food waste becomes an unintended but systematic outcome. For example, fixed portion policies may result in unavoidable leftovers, while limited dining hours can force students to discard food due to scheduling conflicts.

The absence of structured waste reduction initiatives, including awareness campaigns, trayless dining programs, portion control strategies, and food redistribution systems, may further reinforce wasteful consumption behavior (Papargyropoulou *et al*., 2014). Institutional theory therefore broadens the analysis of food waste by highlighting that sustainable food consumption depends not only on individual responsibility but also on the policies and operational practices of organizations.

2.4. Behavioral Economics Perspective on Food Waste

Behavioral economics integrates psychological insights into traditional economic models to explain deviations from purely rational decision-making (Kahneman, 2011; Ozanne *et al*., 2022). Unlike classical economic theory, which assumes that individuals consistently make optimal choices, behavioral economics recognizes that decisions are often influenced by cognitive biases, heuristics, habits, and emotional responses.

In the context of food consumption, behavioral biases such as over-optimism, present bias, and loss aversion significantly influence food waste behavior. University students may overestimate their future appetite, leading them to purchase or serve more food than they can consume. Present bias encourages immediate gratification, such as selecting larger portions or multiple food items, without adequately considering the likelihood of future waste. Similarly, food that is perceived to be less fresh or slightly less appealing may be discarded prematurely despite remaining edible (Aschemann-Witzel *et al*., 2015).

Behavioral economics also emphasizes the importance of default options and choice architecture. Automatically providing large portion sizes, bundled meal deals, or fixed menus can increase food waste even in the absence of deliberate wasteful intentions. By understanding these behavioral tendencies, policymakers and university administrators can develop effective behavioral "nudges" that encourage more sustainable consumption patterns. Interventions such as smaller default portion sizes, improved menu flexibility, better information provision, and food waste awareness campaigns can help reduce waste without restricting consumer choice.

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Taken together, the economic theory of consumer behavior, the Theory of Planned Behavior, institutional theory, and behavioral economics provide a comprehensive and complementary framework for understanding food waste among young consumers. These theoretical perspectives demonstrate that food waste is driven by the interaction of economic incentives, psychological motivations, social influences, and institutional arrangements, thereby providing a strong conceptual foundation for the empirical investigation undertaken in this study.

3. Global Evidence on Food Waste

Food waste is widely recognized as one of the most significant global challenges affecting food security, economic stability, and environmental sustainability. Despite improvements in agricultural productivity and food supply systems, a substantial proportion of food produced for human consumption is lost or wasted every year across different stages of the food supply chain (Gustavsson *et al.*, 2011). While food losses often occur during production, storage, and transportation, recent research has increasingly focused on waste generated at the consumption stage, as this accounts for a considerable share of total food destruction, particularly in urban and institutional settings (Gustavsson *et al*., 2011). Understanding the magnitude, patterns, and implications of food waste at the global level is essential for designing effective waste reduction strategies and promoting sustainable food systems.

3.1. Magnitude and Patterns of Food Waste Worldwide

Globally, food waste occurs in both developed and developing countries, although its scale and characteristics vary considerably across regions. According to the Food and Agriculture Organization (FAO), nearly one-third of all food produced for human consumption is either lost or wasted annually (Gustavsson *et al.*, 2011). This level of waste represents a substantial inefficiency within global food systems and poses serious challenges for food security and sustainable resource management.

The patterns of food waste differ according to income levels, dietary habits, and the organization of food systems. In many countries, a significant proportion of food waste occurs at the household and food service levels, including restaurants, hotels, and institutional cafeterias (Thyberg & Tonjes, 2016). Empirical studies indicate that highly perishable food items, such as fruits, vegetables, prepared meals, and bakery products, are among the most frequently wasted commodities. At the consumption stage, behaviors such as over-serving, inadequate meal planning, excessive purchasing, and limited awareness of the consequences of food waste contribute substantially to overall waste generation (Graham-Rowe *et al*., 2015; Aschemann-Witzel *et al*., 2015; Knezevic *et al*., 2019; Kaur *et al*., 2021). Food waste is particularly prevalent in settings where food is relatively affordable, readily accessible, or provided through fixed-portion systems, such as universities and workplace dining facilities.

3.2. Food Waste in Developed and Developing Countries

The literature identifies important differences in food waste patterns between developed and developing countries. In high-income economies, food waste is concentrated largely at the retail and consumption stages, where edible food is frequently discarded due to aesthetic standards, oversized portions, changing consumer preferences, and convenience-oriented lifestyles (Parfitt *et al*., 2010). Higher income levels and evolving consumption patterns further reinforce these trends, making food waste primarily a behavioral and attitudinal issue rather than one of food availability (Secondi *et al*., 2015).

By contrast, food waste and food loss in developing countries have historically been associated with inefficiencies at the production, post-harvest, storage, and transportation stages because of inadequate infrastructure, limited access to technology, and weak supply chain management. However, recent evidence suggests that consumption-stage food waste is increasing in many developing countries due to rapid urbanization, rising incomes, changing dietary habits, and the expansion of institutional food services. In urban and educational settings, greater availability of prepared food, changing lifestyles, and increasing reliance on cafeterias and canteens have contributed to growing levels of consumer food waste. As a result,

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the distinction between developed and developing countries is becoming less pronounced, with behavioral and institutional factors playing an increasingly important role across both contexts.

3.3. Environmental and Economic Consequences of Food Waste

Global literature consistently highlights the severe environmental, economic, and social consequences of food waste. From an environmental perspective, wasted food represents a substantial loss of valuable natural resources, including land, water, energy, labor, and agricultural inputs that were invested in its production, processing, and distribution (Gustavsson *et al*., 2011). Furthermore, the disposal of food waste generates significant greenhouse gas emissions, particularly methane released during the decomposition of organic waste in landfills, thereby contributing to climate change and environmental degradation (Gustavsson *et al.*, 2011).

From an economic standpoint, food waste imposes considerable financial costs on households, businesses, institutions, and national economies. Resources allocated to food production, transportation, storage, and preparation are effectively squandered when food is discarded before consumption (Thyberg & Tonjes, 2016). In institutional settings such as universities, food waste not only increases operational and procurement costs but also reduces the overall efficiency of food service systems and resource utilization.

The social and ethical implications of food waste are equally significant. In many parts of the world, particularly in regions affected by poverty and food insecurity, the disposal of edible food stands in sharp contrast to the persistent inability of vulnerable populations to meet their nutritional requirements. This contradiction has intensified calls for more sustainable consumption patterns and more efficient food management practices at individual, institutional, and policy levels.

Overall, the global evidence demonstrates that food waste is a complex and multidimensional phenomenon shaped by the interaction of consumer behavior, institutional practices, and broader socio-economic conditions. The patterns and consequences identified in the international literature provide an essential foundation for understanding food waste in specific contexts, particularly among young consumers and within university environments in developing countries such as Pakistan.

4. Food Waste in Developing Countries and Pakistan

Food waste in developing countries has traditionally been associated with losses occurring at the production, storage, transportation, and distribution stages of the food supply chain due to inadequate infrastructure, limited technological capacity, and weak cold-chain systems. However, recent research indicates that consumption-stage food waste is becoming an increasingly important challenge, particularly in rapidly urbanizing societies where changing lifestyles and dietary patterns are reshaping food consumption behavior (Gustavsson *et al.*, 2011; Thi *et al*., 2015). Institutional environments such as universities, hostels, and cafeterias are emerging as significant sources of food waste because they combine large-scale food provisioning with dynamic and often unpredictable consumption patterns.

The growing concern over food waste among young consumers is especially relevant in developing countries, where the coexistence of food insecurity and increasing levels of edible food disposal presents a major sustainability paradox. Rising incomes, greater availability of prepared and convenience foods, urban migration, and evolving social norms have altered food consumption habits among university students and other young adults. These trends have increased the importance of understanding the behavioral and institutional drivers of food waste within educational institutions, where daily food consumption is concentrated and intervention opportunities are readily accessible.

4.1. Food Waste in South Asia

Evidence from South Asian countries suggests that food waste at the consumption stage is increasing, particularly among university students and urban youth populations. Studies indicate that factors such as inadequate meal planning, oversized portions, irregular eating schedules, and limited awareness regarding the economic and environmental consequences of food waste contribute significantly to plate waste in

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institutional settings (Aschemann-Witzel *et al*., 2015). Universities, where students often rely on cafeterias and hostel dining facilities, provide an environment in which convenience frequently takes precedence over efficient food utilization.

Institutional characteristics also play a crucial role in shaping food waste behavior across South Asia. Fixed portion sizes, limited menu flexibility, buffet-style serving systems, and standardized meal plans often result in food quantities that exceed actual consumption needs. Although many students are aware of broader concerns related to food security and environmental sustainability, this awareness does not always translate into responsible consumption practices. Social norms, peer influence, group dining behavior, and convenience-oriented food choices frequently override intentions to minimize waste (Stancu *et al*., 2016). These findings suggest that food waste among university students is influenced by a complex interaction of individual behavior and institutional arrangements rather than by knowledge deficits alone.

4.2. Food Waste Trends and Challenges in Pakistan

In Pakistan, most of the existing research on food waste has concentrated on household-level waste and post-harvest losses within agricultural supply chains. Comparatively little attention has been given to consumption-stage food waste, particularly within higher education institutions. Nevertheless, emerging evidence suggests that food waste is becoming an increasingly significant issue in urban universities, where food is readily available through cafeterias, hostels, and nearby restaurants and cafés (Gustavsson *et al.*, 2011).

Studies focusing on Pakistani university students identify several determinants of food waste, including limited awareness of appropriate portion sizes, a preference for taste and variety over necessity, irregular meal schedules, and insufficient concern for the management of leftovers. Institutional factors further intensify the problem. Large serving portions, inconsistent food quality, limited menu choices, and the absence of formal food waste management or redistribution programs contribute to higher levels of plate waste in university dining facilities. In addition, cultural norms emphasizing hospitality, generosity, and food abundance may unintentionally encourage over-serving and the disposal of edible food (Thi *et al*., 2015).

Economic considerations also influence food waste behavior among students. Subsidized cafeteria meals and limited direct financial responsibility reduce the perceived economic cost of wasting food, weakening incentives for careful consumption. Moreover, demanding academic schedules, time constraints, and the pressures of university life often discourage students from planning meals effectively or utilizing leftovers. As a result, food waste among university students in Pakistan emerges as a multidimensional issue shaped by the interaction of behavioral, economic, cultural, and institutional factors.

Overall, the evidence from developing countries, South Asia, and Pakistan highlights a gradual shift in the food waste discourse from a narrow focus on supply-chain inefficiencies toward a broader understanding that also encompasses consumption-stage waste. This transition underscores the importance of examining food waste within universities, where both individual behaviors and institutional practices can be targeted through evidence-based interventions to promote more sustainable food consumption patterns.

5. Food Waste in Institutional and University Settings

Institutional settings have emerged as important focal points in food waste research, particularly universities where large numbers of students consume meals daily. University campuses typically encompass multiple food service environments, including cafeterias, hostels, canteens, and event-based catering facilities, all of which generate substantial quantities of food waste. High food availability, standardized portion sizes, bulk meal preparation, and institutional serving practices often contribute to the accumulation of edible food waste (Whitehair *et al*., 2013). Given the concentration of young consumers and structured food service systems, universities provide a unique context for understanding food waste behavior and for designing effective waste reduction strategies that can promote sustainable consumption practices.

5.1. Food Waste in Universities and Cafeterias

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University cafeterias are among the primary sources of food waste within institutional settings. Research indicates that large portion sizes, buffet-style dining systems, and limited flexibility in meal selection frequently result in excessive plate waste (Parizeau *et al*., 2015). Students often select or are served more food than they can consume, particularly when meals are provided in predetermined portions or through fixed meal plans that do not accommodate individual preferences and appetites.

Empirical evidence further suggests that institutional factors such as poor food quality, limited menu diversity, and time constraints significantly influence food waste generation in university dining facilities (Stancu *et al*., 2016). Students may discard meals that fail to meet their expectations regarding taste, freshness, or variety, while busy academic schedules often prevent them from completing meals or returning for later consumption. Moreover, when food prices are subsidized, students may perceive food as less economically valuable, reducing the incentive to minimize waste and increasing the likelihood of food disposal.

5.2. Hostel, Canteen, and Event-Based Food Waste

Food waste is also prevalent in university hostels and canteens, where meals are commonly prepared in bulk to cater for large student populations. Standardized serving sizes and fixed meal schedules may generate significant amounts of uneaten food, particularly when students skip meals due to academic responsibilities, extracurricular activities, or personal preferences (Papargyropoulou *et al*., 2014). In many cases, food prepared to ensure adequate supply remains unconsumed and is ultimately discarded.

Event-based food waste represents another important but often overlooked dimension of institutional food waste. Academic conferences, seminars, workshops, student gatherings, and other campus events frequently involve catering services that prepare food in excess to avoid shortages. Consequently, considerable quantities of edible food remain unused after these events and are disposed of rather than redistributed. Existing studies indicate that the absence of structured food recovery and redistribution systems within universities contributes significantly to the unnecessary disposal of surplus food (Thyberg & Tonjes, 2016). Establishing mechanisms for food donation and redistribution could therefore play an important role in reducing institutional food waste while simultaneously supporting local food security initiatives.

5.3. Comparative Evidence from Higher Education Institutions

Comparative research across higher education institutions demonstrates that food waste patterns vary according to institutional policies, dining systems, and socio-cultural contexts. Universities that have implemented targeted waste reduction initiatives, such as trayless dining programs, portion control measures, awareness campaigns, and sustainable food service practices, generally report lower levels of food waste than institutions without such interventions (Whitehair *et al*., 2013).

Cross-country studies comparing universities in Europe, North America, and Asia further highlight the effectiveness of combining behavioral interventions with institutional management strategies to reduce food waste (Secondi *et al*., 2015). Educational campaigns that enhance student awareness, coupled with operational reforms such as flexible portion sizing, improved menu planning, and efficient inventory management, have been shown to significantly reduce waste generation. These findings suggest that successful food waste management in higher education institutions requires an integrated approach that addresses both individual consumption behavior and the structural characteristics of campus food systems.

Overall, the existing literature identifies universities as critical settings for addressing food waste due to their large student populations, organized food service operations, and potential to influence long-term consumption habits. Investigating food waste within institutional environments therefore provides valuable insights for developing evidence-based interventions aimed at promoting sustainable food consumption and reducing unnecessary food loss among young consumers.

6. Determinants of Food Waste

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Food waste is a multifaceted phenomenon influenced by a complex interaction of socio-demographic, behavioral, institutional, and economic factors. Empirical studies suggest that food waste behavior is not uniform across populations but varies according to differences in age, income, education, dietary habits, awareness levels, social norms, and the broader institutional environment (Thyberg & Tonjes, 2016). In university settings, where food is often readily available through subsidized cafeterias and hostels, these factors interact to shape students' food consumption and disposal practices. Understanding the determinants of food waste is therefore essential for designing targeted interventions and effective institutional policies aimed at promoting sustainable consumption.

6.1. Socio-Demographic Determinants

Socio-demographic characteristics are among the most fundamental drivers of food waste behavior because they influence individuals' consumption habits, awareness, preferences, and decision-making processes. Variables such as age, income, education, and dietary patterns have been widely recognized in the literature as significant predictors of food waste generation.

Age, Income, Education, and Dietary Habits

Age plays an important role in shaping food waste behavior. Younger individuals, particularly university students, tend to generate more waste than older populations, largely because of limited experience in meal planning, irregular eating schedules, and a stronger preference for convenience foods (Secondi *et al*., 2015). Student lifestyles, often characterized by changing routines and limited attention to food management, further contribute to higher levels of waste.

Income level also affects food waste patterns. Individuals with higher incomes are generally less sensitive to food costs and may waste larger quantities of food because the perceived economic loss associated with disposal is relatively low. Conversely, those with limited financial resources tend to manage food more carefully and generate less waste (Aschemann-Witzel *et al*., 2015). Within university environments, subsidized meal systems can similarly reduce students' perception of the economic value of food, increasing the likelihood of wasteful behavior.

Education represents another important determinant. Higher levels of education are often associated with greater awareness of the environmental, social, and economic implications of food waste. However, empirical evidence consistently suggests that increased awareness does not necessarily translate into reduced food waste, highlighting a persistent gap between knowledge and actual behavior (Stancu *et al*., 2016).

Dietary habits and food preferences further shape waste generation. Students who seek greater variety in their meals or frequently change their food choices may be more likely to discard leftovers. Likewise, irregular eating patterns, meal skipping, and dependence on ready-made or cafeteria meals increase the probability of food waste (Parizeau *et al*., 2015). Overall, the literature demonstrates that socio-demographic factors exert a substantial influence on food waste behavior, particularly among university students, while interacting closely with behavioral and institutional determinants.

6.2. Behavioral and Attitudinal Determinants

Behavioral and attitudinal factors are among the most widely studied determinants of food waste, especially in educational institutions. These factors influence how individuals perceive food, make consumption decisions, and manage leftovers. Existing evidence highlights that awareness, attitudes, social norms, food preferences, portion sizes, and daily consumption practices collectively shape food waste patterns (Stancu *et al*., 2016).

Awareness, Attitudes, Social Norms, and Food Preferences

Awareness of the environmental, economic, and social consequences of food waste is often considered a prerequisite for responsible consumption behavior. Students who possess greater knowledge about the impacts of food waste are generally more inclined to adopt waste-reducing practices. Nevertheless, research

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indicates that awareness alone is insufficient to ensure behavioral change, revealing a significant gap between knowledge and actual practice (Visschers *et al*., 2016).

Attitudes toward food conservation and sustainability also play a critical role. Positive attitudes are generally associated with lower levels of food waste, whereas indifferent or careless attitudes contribute to higher levels of disposal (Stancu *et al*., 2016). In addition, social norms significantly influence food consumption patterns. Students are often affected by peer behavior and shared dining practices, and in group settings they may overserve or waste food to conform to social expectations.

Food preferences and taste are equally important determinants. Students may discard meals that do not satisfy their taste preferences or may choose a variety of menu items while leaving some portions uneaten. Such preference-driven decisions are particularly common in buffet-style and cafeteria dining environments where multiple food options are available.

Portion Size, Plate Waste, and Consumption Behavior

Portion size is consistently identified as a major determinant of food waste in institutional settings. Empirical studies show that larger serving sizes are directly associated with increased plate waste because individuals are often unable to consume all the food provided (Whitehair *et al*., 2013). Fixed portion systems and limited flexibility in meal customization further exacerbate this problem.

Consumption behavior, including impulsive food selection, overeating tendencies, and poor meal planning, also contributes significantly to food waste. Students frequently overestimate their appetite and select more food than required, resulting in leftovers that are eventually discarded (Parizeau *et al*., 2015). Plate waste is particularly common in university cafeterias where convenience, time constraints, and social dining habits shape consumption patterns. Furthermore, irregular meal schedules and meal skipping often lead to food remaining unused or becoming spoiled before consumption. These findings suggest that improvements in portion control, increased awareness, and the promotion of responsible eating practices can substantially reduce food waste within university settings.

6.3. Economic Determinants

Economic factors play a pivotal role in shaping food consumption and disposal behavior, particularly in institutional environments where food pricing structures and subsidy mechanisms influence consumer decisions. The literature suggests that when the perceived economic cost of food is low, the likelihood of food waste increases (Thyberg & Tonjes, 2016).

Food Pricing and Subsidies

Food pricing is a key determinant of food waste behavior. Lower food prices reduce the perceived value of food, encouraging individuals to purchase or serve larger quantities than necessary. In university settings, subsidized meals and fixed-price dining systems often motivate students to select larger portions, contributing to higher levels of plate waste (Aschemann-Witzel *et al*., 2015).

Although subsidy-based food systems improve affordability and accessibility, they may unintentionally encourage waste by reducing the financial incentive to conserve food. Students may not fully internalize the economic cost of discarded food when meals are subsidized or incorporated into prepaid meal plans. Consequently, the economic disincentive for wasting food remains weak, leading to inefficient consumption patterns (Parizeau *et al*., 2015).

Budg*et al*location and Resource Efficiency

Budg*et al*location and resource management influence food waste at both the individual and institutional levels. Students operating under limited personal budgets generally adopt more cautious food management practices, whereas those with greater financial flexibility often exhibit higher levels of waste (Secondi *et al*., 2015). Financial constraints can therefore act as a natural mechanism for reducing unnecessary consumption and improving resource utilization.

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At the institutional level, inefficient budg*et al*location and food service management practices may contribute to overproduction and excess food supply. Universities frequently prepare food in large quantities to avoid shortages, but this practice often results in significant amounts of surplus food being discarded. Such inefficiencies reflect shortcomings in demand forecasting, inventory management, and portion planning, highlighting the need for more effective resource allocation strategies (Papargyropoulou *et al*., 2014; Bittner *et al., 2025*).

Overall, the literature demonstrates that economic determinants influence food waste through both individual consumption decisions and institutional management practices. Addressing issues related to food pricing, subsidy structures, demand forecasting, and resource efficiency can therefore play a significant role in reducing food waste within university environments and promoting more sustainable food systems.

7. Measurement Approaches to Food Waste

The accurate measurement of food waste is essential for understanding its magnitude, identifying its primary sources, and designing effective interventions to reduce waste generation. Reliable measurement not only provides evidence on the scale of the problem but also enables researchers and policymakers to evaluate the effectiveness of food waste reduction initiatives over time. In institutional settings such as universities, a combination of quantitative and qualitative approaches is commonly employed to assess food waste behavior and disposal patterns. Each method offers distinct advantages while also presenting certain limitations that must be considered in empirical research (Xue *et al*., 2017).

7.1. Quantitative Measurement Approaches

Quantitative methods are widely used to estimate the volume and composition of food waste generated within institutional settings. Among these, waste audits and direct weighing techniques are generally regarded as the most reliable methods because they provide objective and accurate information on the amount and type of food discarded (Gustavsson *et al*., 2011). In university cafeterias, plate waste is frequently measured by collecting and weighing leftover food after meals, allowing researchers to quantify waste levels and identify the food items most discarded.

Surveys and structured questionnaires represent another important quantitative approach to measuring food waste behavior. These tools are used to gather information on students' food consumption habits, portion selection, meal planning practices, and self-reported waste behavior. Survey-based methods are particularly useful for collecting data from large populations at relatively low cost. However, they are subject to certain limitations, including reporting bias and recall errors, as respondents may underestimate or inaccurately report the amount of food they waste (Xue *et al*., 2017). Despite these shortcomings, surveys remain a valuable complement to direct measurement techniques because they provide insights into the factors underlying waste generation.

7.2. Qualitative Measurement Approaches

Qualitative methods are primarily employed to explore the underlying reasons and motivations behind food waste behavior. Unlike quantitative techniques, which focus on measuring the amount of waste generated, qualitative approaches seek to understand why individuals waste food and how social, cultural, and institutional factors shape their decisions.

Interviews provide researchers with the opportunity to examine students' attitudes, perceptions, and beliefs regarding food consumption and waste. Through in-depth discussions, participants can explain the factors influencing their meal choices, leftover management practices, and awareness of the environmental and economic consequences of food waste. Similarly, observational methods, such as monitoring cafeteria or canteen behavior, allow researchers to record real-time food selection, serving, and disposal practices without relying solely on self-reported information (Papargyropoulou *et al*., 2014).

These qualitative approaches are particularly valuable for identifying behavioral and institutional determinants that may not be adequately captured through quantitative data alone. They provide contextual

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understanding of food waste practices and help explain the social and organizational dynamics that contribute to waste generation in university settings.

7.3. Limitations of Food Waste Measurement in Institutional Settings

Despite the availability of various measurement techniques, assessing food waste in institutional environments presents several methodological challenges. Direct measurement methods, including waste audits and plate-weighing exercises, are often labor-intensive, time-consuming, and require substantial logistical and financial resources. Implementing these methods on a large scale can therefore be difficult, particularly in universities with multiple dining facilities and large student populations.

Survey-based approaches also have limitations. Self-reported data may suffer from recall bias and social desirability bias, as respondents often underreport behaviors perceived as socially undesirable, including food waste (Xue *et al*., 2017). As a result, survey estimates may not accurately reflect actual waste levels.

In addition, variations across university dining systems, serving practices, portion sizes, and student lifestyles create further challenges for obtaining standardized and comparable measurements. The absence of universally accepted measurement protocols also limits the comparability of findings across different studies and institutional contexts. Consequently, many scholars recommend the use of mixed method approaches that combine quantitative techniques, such as waste audits and surveys, with qualitative methods, including interviews and observations, to produce more comprehensive and reliable assessments of food waste (Papargyropoulou *et al*., 2014; Aydin & Yildirim, 2020).

Overall, the literature suggests that no single method can fully capture the complexity of food waste behavior. Integrating multiple measurement approaches provides a more robust understanding of both the scale of food waste and the underlying factors that drive it, thereby supporting the development of more effective and evidence-based waste reduction strategies in university settings.

8. Research Gaps Identified from Literature

The preceding review of the literature demonstrates that food waste has emerged as an important area of research because of its implications for food security, environmental sustainability, and resource efficiency. Although a substantial body of work has examined the causes and consequences of food waste, several important gaps remain, particularly within the context of developing countries such as Pakistan. Existing studies have primarily focused on household-level food waste and supply chain losses, while relatively limited attention has been devoted to food waste occurring within institutional environments, especially universities (Thyberg & Tonjes, 2016). The literature review identifies three major gaps that provide the rationale for the present study.

8.1. Lack of Micro-Level Evidence from Pakistani Universities

One of the most significant limitations in the existing literature is the scarcity of micro-level empirical evidence from higher education institutions in Pakistan. Most available studies present broad or generalized findings regarding food waste and do not comprehensively investigate student-specific behaviors, consumption patterns, and waste management practices. Consequently, there is limited understanding of how individual characteristics, dietary habits, and daily campus routines influence food waste generation among university students.

Moreover, most previous studies have relied on national or household-level data, which may not adequately capture the unique dynamics of institutional food environments. Universities represent a distinct setting where subsidized meals, cafeteria services, hostel dining systems, and changing student lifestyles collectively shape food consumption behavior. The absence of detailed campus-level evidence restricts the development of targeted interventions and limits the ability of policymakers and university administrators to formulate evidence-based strategies for reducing food waste.

8.2. Limited Focus on Institutional Determinants

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A second major gap concerns the relatively limited attention given to institutional and organizational determinants of food waste. Existing research has predominantly emphasized individual-level behavioral factors such as awareness, attitudes, environmental concern, and personal responsibility. While these factors are undoubtedly important, they do not fully explain the variation in food waste observed across different institutional settings.

The literature provides comparatively little analysis of how cafeteria systems, portion sizes, food quality, menu flexibility, serving practices, and dining schedules influence food waste generation (Papargyropoulou *et al*., 2014; Alattar *et al*., 2020). Similarly, the role of institutional policies, food service management, and operational inefficiencies remains underexplored, particularly in developing-country universities. Since food waste is shaped by the interaction between individual choices and the institutional environment, a more integrated analytical approach is required to understand the relative contribution of these factors.

8.3. Absence of Campus-Level Policy Evaluations

Another notable gap in the literature is the limited evaluation of food waste reduction initiatives implemented within university settings. Although various interventions such as awareness campaigns, portion control measures, trayless dining systems, and food redistribution programs have been proposed or introduced in different countries, few studies have systematically assessed their effectiveness in reducing food waste.

The absence of rigorous evaluations makes it difficult to identify which policy instruments and institutional practices are most effective in promoting sustainable food consumption among university students. This limitation is particularly evident in Pakistan, where empirical evidence on the implementation and outcomes of campus-level food waste management strategies remains extremely limited. As a result, universities often lack practical guidance for designing and implementing evidence-based food waste reduction programs.

8.4. Research Contribution and Study Rationale

Addressing these gaps is essential for advancing both the academic understanding and practical management of food waste in higher education institutions. The present study contributes to the literature by providing micro-level empirical evidence from Government College Women University Sialkot (GCWUS), with a particular focus on the interaction between behavioral and institutional determinants of food waste. Unlike many previous studies that emphasize either individual attitudes or generalized national trends, this research adopts an integrated perspective that examines how socio-demographic characteristics, behavioral factors, economic considerations, and institutional arrangements collectively shape food waste behavior among university students.

By generating context-specific evidence from a developing-country setting, the study seeks to fill an important gap in the existing literature and provide a foundation for the development of targeted policies and sustainable food waste management practices within Pakistani universities.

9. Conclusion

This chapter has critically reviewed the existing body of knowledge on food waste with a particular focus on young consumers and university students in developing countries. The literature demonstrates that food waste is a multidimensional and systemic issue that extends beyond individual carelessness and is shaped by the interaction of economic incentives, behavioral intentions, social norms, institutional practices, and broader food system characteristics. Theoretical perspectives, including the economic theory of consumer behavior, the Theory of Planned Behavior, institutional theory, and behavioral economics, collectively provide a robust framework for understanding why food waste persists even among individuals who are aware of its adverse consequences. These perspectives highlight that food waste behavior is influenced not only by personal attitudes and preferences but also by contextual factors such as pricing structures, portion sizes, social expectations, convenience, and the design of institutional food service systems.

The empirical evidence reviewed in this chapter reveals that food waste among university students is associated with a wide range of determinants, including socio-demographic characteristics, dietary habits,

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environmental awareness, attitudes toward sustainability, peer influence, and economic considerations. Institutional factors such as cafeteria management practices, food quality, menu flexibility, serving systems, and standardized portion sizes also play a critical role in shaping food waste outcomes. The literature further shows that while developed countries have long recognized consumption-stage food waste as a major challenge, developing countries are increasingly facing similar problems due to rapid urbanization, changing lifestyles, expanding food service sectors, and evolving consumption patterns among younger populations. In countries such as Pakistan, where concerns regarding food insecurity and resource scarcity remain acute, the growing incidence of food waste within educational institutions presents both a sustainability challenge and a missed opportunity for improving resource efficiency.

The chapter also highlights the importance of reliable food waste measurement and the need for combining quantitative and qualitative approaches to capture both the magnitude of waste and the underlying behavioral and institutional drivers. Existing measurement methods provide useful insights but often face limitations related to data availability, self-reporting biases, and the absence of standardized methodologies, particularly in institutional settings. This reinforces the need for context-specific empirical investigations that employ comprehensive and methodologically sound approaches.

A major contribution of this literature review is the identification of significant research gaps. Existing studies have largely focused on household food waste or supply chain losses, with comparatively little attention devoted to university environments in developing countries. Micro-level evidence from Pakistani higher education institutions remains scarce, and limited research has examined the influence of institutional arrangements such as cafeteria operations, portion control, and campus food policies. Likewise, there is a notable lack of empirical evaluation of food waste reduction initiatives, including awareness campaigns, food redistribution mechanisms, and behavioral interventions. Addressing these gaps is essential for developing evidence-based strategies capable of reducing food waste while promoting sustainable consumption practices among young consumers.

Drawing together the theoretical perspectives, empirical findings, and identified research gaps, this chapter provides the conceptual and analytical foundation for the present study. The proposed conceptual framework recognizes that food waste among university students is the outcome of the interaction between socio-demographic, behavioral, economic, and institutional factors, all of which jointly influence food consumption and disposal practices. By focusing on the context of GC Women University Sialkot, the study seeks to contribute original empirical evidence from a developing country perspective and to generate practical insights for policymakers, university administrators, and other stakeholders seeking to reduce food waste and advance sustainability within higher education institutions. Ultimately, tackling food waste among young consumers is not only a matter of improving resource efficiency but also an essential step toward achieving broader goals of food security, environmental sustainability, and responsible consumption.

References

Bittner, B., Vida, V., Szakos, D., Kasza, G., Kovács, S., & Nagy, A. 2025, A study of the behavioral and environmental factors influencing food waste in higher education. *Cleaner Waste Systems*, vol. 11, Art. no. 100256. https://doi.org/10.1016/j.clwas.2025.100256

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Alattar, M. A., DeLaney, J., Morse, J. L., & Nielsen-Pincus, M. (2020). Food waste knowledge, attitudes, and behavioral intentions among university students. *Journal of Agriculture, Food Systems, and Community Development, 9*(3), 1–18. https://doi.org/10.5304/jafscd.2020.093.014

Aschemann-Witzel, J., de Hooge, I., Amani, P., Bech-Larsen, T., & Oostindjer, M. (2015). Consumer-related food waste: Causes and potential for action. *Sustainability, 7*(6), 6457–6477. https://doi.org/10.3390/su7066457

Aydin, H., & Yildirim, P. (2020). Understanding food waste behavior: The role of morals, habits and knowledge. *Journal of Cleaner Production, 280*, Article 124250. https://doi.org/10.1016/j.jclepro.2020.124250

Becker, G. S. (1965). A theory of the allocation of time. *The Economic Journal, 75*(299), 493–517. https://doi.org/10.2307/2228949

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Graham-Rowe, E., Jessop, D. C., & Sparks, P. (2015). Predicting household food waste reduction using an extended theory of planned behaviour. *Resources, Conservation and Recycling, 101*, 194–202. https://doi.org/10.1016/j.resconrec.2015.05.020

Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R., & Meybeck, A. (2011). *Global food losses and food waste: Extent, causes and prevention*. Food and Agriculture Organization of the United Nations. https://www.fao.org/4/mb060e/mb060e.pdf

Kahneman, D. (2011). *Thinking, fast and slow*. Farrar, Straus and Giroux. https://link.springer.com/article/10.1007/s00362-013-0533-y

Kaur, P., Dhir, A., Talwar, S., & Ghuman, K. (2021). Systematic literature review of food waste in educational institutions. *International Journal of Contemporary Hospitality Management, 33*(4), 1161–1184. http://dx.doi.org/10.1108/IJCHM-07-2020-0672

Knezevic, B., Kurnoga, N., & Anic, I. D. (2019). Typology of university students regarding attitudes toward food waste. *British Food Journal, 121*(11), 2578–2591. https://doi.org/10.1108/BFJ-05-2018-0316

Long, Q. Feng, Li., Baoming, C., Lingen, W., & Shaosheng J. (2021). Determinants of food waste generation in Chinese university canteens. *Resources, Conservation and Recycling, 167*, Article 105410. https://doi.org/10.1016/j.resconrec.2021.105410

Ozanne, L. K., Ballantine, P. W., & McMaster, A. (2022). Understanding food waste produced by university students: A social practice approach. *Sustainability, 14*(17), Article 10653. https://doi.org/10.3390/su141710653

Papargyropoulou, E., Lozano, R., Steinberger, J. K., Wright, N., & Ujang, Z. (2014). The food waste hierarchy as a framework for the management of food surplus and food waste. *Journal of Cleaner Production, 76*, 106–115. https://doi.org/10.1016/j.jclepro.2014.04.020

Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: Quantification and potential for change to 2050. *Philosophical Transactions of the Royal Society B: Biological Sciences, 365*(1554), 3065–3081. https://doi.org/10.1098/rstb.2010.0126

Parizeau, K., von Massow, M., & Martin, R. (2015). Household-level dynamics of food waste production and related beliefs, attitudes, and behaviours in Guelph, Ontario. *Waste Management, 35*, 207–217. https://doi.org/10.1016/j.wasman.2014.09.019

Scott, W. R. (2008). *Institutions and organizations: Ideas and interests* (3rd ed.). Sage Publications. https://digitalcommons.usu.edu/unf_research/55/

Secondi, L., Principato, L., & Laureti, T. (2015). Household food waste behaviour in EU-27 countries: A multilevel analysis. *Food Policy, 56*, 25–40. https://doi.org/10.1016/j.foodpol.2015.07.007

Stancu, V., Haugaard, P., & Lahteenmaki, L. (2016). Determinants of consumer food waste behaviour: Two routes to food waste. *Appetite, 96*, 7–17. https://doi.org/10.1016/j.appet.2015.08. 025

Thi, N. B. D., Kumar, G., & Lin, C. Y. (2015). An overview of food waste management in developing countries: Current status and future perspective. *Journal of Environmental Management, 157*, 220–229. https://doi.org/10.1016/j.jenvman.2015.04.022

Thyberg, K. L., & Tonjes, D. J. (2016). Drivers of food waste and their implications for sustainable policy development. *Resources, Conservation and Recycling, 106*, 110–123. https://doi.org/10.1016/j.resconrec.2015.11.016

Visschers, V. H. M., Wickli, N., & Siegrist, M. (2016). Sorting out food waste behaviour: A survey on the motivators and barriers of self-reported amounts of food waste in households. *Journal of Environmental Psychology, 45*, 66–78. https://doi.org/10.1016/j.jenvp.2015.11.007

Whitehair, K. J., Shanklin, C. W., & Brannon, L. A. (2013). Written messages improve edible food waste behaviors in a university dining facility. *Journal of the Academy of Nutrition and Dietetics, 113*(1), 63–69. https://doi.org/10.1016/j.jand.2012.09.015

Xue, L., Liu, G., Parfitt, J., Liu, X., Van Herpen, E., Stenmarck, Å., O'Connor, C., Östergren, K., & Cheng, S. (2017). Missing food, missing data? A critical review of global food losses and food waste data. *Environmental Science & Technology, 51*(12), 6618–6633. https://doi.org/10.1021/acs.est.7b00401

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CHAPTER 21

Insects and Food Security in Developing Economies: Threat, Opportunity, and the Institutions That Decide Which Prevails

Muhammad Hamid Bashir[1,*] & Muhammad Dildar Gogi[1]
[1]Department of Entomology, University of Agriculture, Faisalabad, Pakistan
Corresponding author's email: h.bashir@uaf.edu.pk

Abstract

Insects occupy a paradoxical position in food security science. They are simultaneously among the most destructive forces acting against food systems and among the most underexploited resources for strengthening them. Pre-harvest pest damage and postharvest storage losses attributable to insects remove a substantial share of the food that developing economies produce before it ever reaches a plate. While, at the same time, insects themselves represent a nutrient-dense, resource-efficient food and feed source that remains largely outside formal food systems and regulatory frameworks. This chapter argues that which of these two faces predominates in any given country is not primarily a biological or technical matter but an institutional one. Drawing on the desert locust upsurge of 2019–2021, the spread of fall armyworm across Asia and Africa, and the slow institutionalization of insect farming and entomophagy in countries such as Thailand, the chapter develops the Insect-Mediated Food Security Framework (IMFSF), which models net food security impact as the difference between institutionally mediated losses avoided and institutionally mediated value captured. The framework is applied in depth to Pakistan, where weak extension delivery, pesticide subsidy distortions, fragmented quarantine authority, and an absent regulatory pathway for insect-based food and feed products together constrain both sides of the ledger. The chapter closes with a sequenced set of governance recommendations addressing surveillance and early warning, integrated pest management institutionalization, and the regulatory foundations needed to convert insects from food security liability into a food security asset.

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1. Introduction

Organizing Question: How do insects simultaneously undermine and offer pathways to strengthen food security in developing economies, and what institutional conditions determine which effect dominates in each country's context?

Food security scholarship has generally treated insects as a peripheral concern, addressed, if at all, under the heading of crop protection, and rarely brought into contact with the central debates over governance, institutions, and political economy that animate the rest of this volume. This treatment understates the scale of the issue. Insects intersect with food security through at least two distinct and largely separate channels. The first is destructive: insect pests reduce the quantity and quality of food available for human consumption at every stage from the field to the storage bin, and a small number of migratory and invasive species can inflict continental-scale damage in a single season. The second is productive: a subset of insect species are edible, nutritionally dense, and can be reared with a fraction of the land, water, and feed inputs required by conventional livestock, offering a potential food and feed resource that most developing economies have neither regulated nor integrated into agricultural or nutrition policy.

This chapter treats these two channels not as separate topics but as two pathways of a single phenomenon, governed by overlapping but distinct sets of institutions. Consistent with the volume's central argument, that food insecurity in developing economies is fundamentally a governance problem rather than a production

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problem, this chapter shows that the same institutional weaknesses that limit the effectiveness of subsidy programs, decentralization, and price stabilization elsewhere in the book also determine whether insects function as a net drain on or a net contribution to national food security. Where extension systems, quarantine authority, and regulatory capacity are strong, pest losses can be substantially contained and emerging opportunities in insect-based food and feed can be captured. Where these institutions are weak, fragmented, or politically compromised, both the loss pathway and the gain pathway underperform simultaneously.

Pakistan is used as the chapter's primary case study, both because it is the volume's dominant geographic focus and because it illustrates the dual failure mode with particular clarity: a country that has experienced significant, institutionally amplified pest losses in the recent past, including the 2019–2020 desert locust upsurge, while simultaneously possessing almost no regulatory or policy architecture for insect-based food or feed, despite favorable agroecological and economic conditions for their development. Comparative evidence from Thailand's cricket farming sector, sub-Saharan Africa's fall armyworm response, and the regulatory approaches of the European Union and the Food and Agriculture Organization (FAO) is used to illustrate what functional institutions look like on both sides of the ledger.

2. The Scale of the Problem: Insect-Mediated Losses in Developing Food Systems

Global estimates place insect-attributable losses among the largest single biotic constraints on realized crop production, alongside pathogens and weeds, with the burden falling disproportionately on the tropical and subtropical regions where most developing economies are located, both because pest pressure is generally higher under warm, humid conditions and because the surveillance, extension, and control infrastructure needed to contain that pressure is generally weaker (Oerke, 2006; Savary *et al*., 2019). This asymmetry means that the same insect species can impose a materially different food security cost depending on where it occurs, a point developed further in Sections 3 and 5.

2.1. Pre-Harvest Losses

Insects are estimated to destroy a substantial proportion of global crop production every year, with losses concentrated disproportionately in developing economies where pest surveillance, extension coverage, and access to timely control measures are weakest (Oerke, 2006; Savary *et al*., 2019). Unlike losses from abiotic stress, insect-driven losses are frequently preventable with timely, well-targeted intervention, which is precisely what makes the scale of realized loss in developing economies an institutional signal rather than a purely biological one. Three pest complexes illustrate the point with force in the South Asian and Pakistani context.

Cotton, historically Pakistan's most important cash crop and export earner, has for decades absorbed a disproportionate share of national pesticide use in response to the cotton bollworm complex and, since the mid-2000s, the cotton mealybug and whitefly-transmitted cotton leaf curl virus complex. Yield losses in poorly managed fields have periodically exceeded a third of potential production, with associated foreign exchange and rural income consequences that extend well beyond the farm gate (Hameed *et al*., 1993; Nawaz *et al*., 2019; Brar & Bhullar, 2022).

Stored-grain pests, chiefly Sitophilus species, Tribolium species, and the khapra beetle, impose losses that are less visible than field-level pest outbreaks but are frequently larger in aggregate, because they act continuously across the storage period rather than in a single seasonal event, and because storage infrastructure in developing economies is frequently informal, poorly ventilated, and lacking basic pest exclusion.

The most dramatic recent illustration of pre-harvest insect risk in the region, however, is the desert locust (Schistocerca gregaria) upsurge of 2019–2021, discussed in detail in Section 2.3, which affected Pakistan alongside East Africa, the Horn of Africa, and parts of the Arabian Peninsula and South Asia simultaneously, and which functioned as a stress test of national and regional pest governance capacity under conditions of genuine transboundary emergency.

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2.2. Postharvest Losses

Post-harvest losses are attributable to insects compound pre-harvest losses and are frequently underestimated in national food balance accounting, because they occur diffusely across millions of individual storage decisions made by smallholder farmers, traders, and processors rather than at a small number of observable points in the supply chain. Estimates for cereal postharvest losses in developing regions, encompassing insect damage alongside fungal spoilage and mechanical loss, commonly range from a fifth to a third of harvested grain under poor storage conditions (Affognon *et al*., 2015; APHLIS, 2021), a magnitude that, if halved, would represent a larger addition to effective food availability than most feasible increases in planted area or yield. Because postharvest loss reduction does not require new land, water, or seed, and because it acts directly on food that has already been produced at real resource cost, it constitutes one of the more institutionally tractable levers available to food security policy, provided storage infrastructure, extension advice on hermetic storage technologies, and market incentives for quality-based pricing are in place.

2.3. Case Study: The 2019–2021 Desert Locust Upsurge as a Governance Stress Test

The desert locust upsurge that began in the Horn of Africa in 2018 and spread across East Africa, the Arabian Peninsula, Iran, and into Pakistan and northwestern India by 2019–2020 was, by most assessments, the most serious locust event in a quarter century (FAO, 2021). Pakistan declared a national emergency in early 2020 after swarms affected Balochistan, Sindh, and southern Punjab, with early estimates suggesting billions of dollars in potential crop and economic losses if the upsurge had not been contained (Government of Pakistan, 2020).

The episode is instructive less for its biology, desert locust population dynamics are comparatively well understood, than for what it revealed about institutional capacity. Locust control depends on continuous field surveillance in remote breeding areas, rapid reporting into regional early warning systems, cross-border data sharing, and the capacity to mobilize aerial and ground control assets before hopper bands fledge into highly mobile swarms. Pakistan's response drew on FAO coordination and international support, and ultimately avoided the catastrophic scenario, but exposed long-standing weaknesses in provincial-federal coordination on plant protection, in the staffing and equipment of the Department of Plant Protection, and in the country's capacity to sustain surveillance during non-emergency periods, when funding and attention for locust monitoring characteristically lapse. This pattern, underinvestment during quiescent periods followed by crisis-driven emergency response, is a recognizable institutional signature that recurs across pest management systems in developing economies and is addressed directly in Section 3.

2.4. Climate Change as a Loss Multiplier

The loss burden documented above is not static. Rising temperatures are projected to expand the geographic range and shorten the generation time of many economically important insect pests, while also altering the synchrony between pest life cycles and crop phenology in ways that existing pest management calendars, built around historical climate patterns, do not anticipate (Deutsch *et al*., 2018). This dynamic connects the present chapter directly to the climate-vulnerability analysis developed in Chapter 11 and the adaptive-governance argument developed in Chapter 12: static pest management institutions, calibrated to a pest complex and geographic distribution that climate change is actively reshaping, will underperform even where they historically performed adequately, unless surveillance and extension systems are redesigned with the scenario-planning and trigger-based logic that Chapter 12 recommends for food security governance more broadly. Fall armyworm's rapid establishment across Asia after its 2016 African detection, aided by the pest's strong flight capacity and broad host range, is itself illustrative of the kind of range expansion that a warming climate is expected to make more common across a wider set of species, reinforcing rather than replacing the institutional argument developed in Section 3.

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3. The Loss Pathway: Why Pest Management Institutions Underperform

3.1. Extension and Surveillance Gaps

Integrated pest management (IPM) has been promoted internationally as the technical standard for pest control since at least the 1970s, combining biological control, resistant varieties, cultural practices, and judicious, targeted pesticide use in place of calendar-based spraying. Its adoption in developing economies, however, has consistently lagged its technical promotion, for reasons that are substantially institutional rather than technical (Parsa *et al*., 2014). Extension services in most developing economies, including Pakistan, are underfunded relative to the geographic and farmer populations they are meant to serve, meaning that farmer-level pest identification and threshold-based decision-making, the foundation of IPM, is frequently replaced by default reliance on prophylactic pesticide application, reinforced by input dealers who have a direct financial incentive to recommend more spraying rather than less.

3.2. Pesticide Subsidy and Market Distortions

Where fertilizer subsidies distort input markets elsewhere in this volume's analysis (Chapter 6), pesticide markets in many developing economies exhibit a related but distinct distortion: weak regulation of the retail pesticide trade allows the proliferation of counterfeit and substandard products, inconsistent enforcement of pre-harvest intervals and restricted-use classifications, and a commission-based sales structure that rewards volume over efficacy. The consequence is a pest management system in which farmers frequently overspend on pesticide inputs while simultaneously achieving suboptimal pest control, a combination that is only fully explained by reference to the incentive structure of the retail input market rather than to farmer knowledge deficits alone.

3.3. Fragmented Quarantine and Regulatory Authority

Plant quarantine and pest surveillance functions in many developing economies, Pakistan included, are split across federal and provincial authorities with overlapping but incompletely coordinated mandates, a pattern that parallels the decentralization risks identified elsewhere in this volume (Chapter 5): unfunded mandates, fragmentation, and exclusion of the technical capacity needed to act on surveillance data even where it exists. Transboundary pests such as fall armyworm (Spodoptera frugiperda), first confirmed in Africa in 2016 and detected across South and Southeast Asia by 2018–2019 (Goergen *et al*., 2016; FAO, 2019), spread in significant part because no developing region possessed the coordinated, real-time surveillance and rapid-response architecture that a genuinely invasive, highly mobile pest requires. Fall armyworm is now established across most of Pakistan's maize-growing areas and functions as a recurring, rather than emergency, drain on maize yields, illustrating how an initial governance failure to prevent or slow an invasion becomes a permanent addition to the baseline loss burden.

3.4. What Functional Institutions Look Like

Not all developing-economy pest governance is weak, and the contrast is informative. National surveillance and early-warning systems that maintain year-round field networks rather than crisis-triggered mobilization, that integrate remote sensing and mobile-based farmer reporting (a theme explored further in Chapter 17's treatment of digital tools), and that combine biological control research capacity with rapid regulatory approval for new biocontrol agents, have demonstrated materially better outcomes against comparable pest pressure. Kenya's post-2016 fall armyworm response, which built on existing plant health surveillance infrastructure developed for earlier pest threats, is frequently cited as a comparatively effective regional model (Day *et al*., 2017), underscoring that the binding constraint is institutional continuity and coordination capacity rather than the availability of the underlying control technologies.

3.5. The Political Economy of Pest Management Reform

The persistence of calendar-based, high-input pesticide reliance despite decades of IPM promotion is best understood, in terms consistent with the political economy framework Chapter 6 applies to subsidy and price-control persistence, as the product of a distributional coalition with a direct stake in the status quo.

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Agrochemical companies and the retail dealer networks through which pesticides reach farmers constitute a well-organized, geographically dispersed interest group with clear incentives to resist reforms that would reduce input volumes, while the diffuse beneficiaries of reduced pesticide overuse, farmers who would save on input costs, downstream consumers exposed to lower pesticide residues, and the environment more broadly, face the classic collective action problem of a benefit too widely dispersed to generate organized political pressure (Olson, 1965, as applied in Chapter 6's framework). This asymmetry helps explain why IPM adoption in developing economies has typically advanced fastest not through broad regulatory reform of the pesticide market, which requires confronting the organized coalition directly, but through donor-funded farmer field school programs that build farmer-level demand for reduced-input approaches without directly challenging the retail input market structure, a second-best but politically more feasible reform pathway that nonetheless leaves the underlying market distortion in place once donor funding ends. A durable solution, consistent with the sequencing logic developed in Section 8, likely requires pairing farmer-facing IPM promotion with parallel, incremental strengthening of pesticide retail regulation and enforcement, so that gains in farmer demand for reduced-input approaches are not undermined by a retail market still structurally biased toward overselling.

4. The Gain Pathway: Insects as an Underexploited Food and Feed Resource

4.1. The Nutritional and Resource-Efficiency Case

A substantial body of research, consolidated most influentially in FAO's 2013 report *Edible Insects: Future Prospects for Food and Feed Security* (van Huis *et al*., 2013), documents that many edible insect species are comparable to or exceed conventional meat sources in protein content and quality, and are frequently rich in essential fatty acids, iron, zinc, and other micronutrients in which diets in food-insecure populations are commonly deficient. The resource-efficiency case is at least as significant for food security purposes as the nutritional case: farmed insects such as crickets and black soldier fly larvae generally require substantially less land, water, and feed per unit of protein produced than cattle, and in some analyses than poultry, while producing a fraction of the greenhouse gas emissions (Oonincx & de Boer, 2012; van Huis, 2013). For land- and water-constrained developing economies facing simultaneous pressure to raise protein availability and manage climate commitments, an efficient protein source that can be produced on marginal land, fed partly on agricultural and food waste streams, and cycled in weeks rather than months represents a genuinely underused asset.

4.2. Entomophagy: Existing Practice and the Acceptance Barrier

Entomophagy, the human consumption of insects, is already practiced by an estimated two billion people worldwide, concentrated in parts of Southeast Asia, sub-Saharan Africa, and Latin America, where insects such as crickets, grasshoppers, termites, and various beetle larvae form a traditional part of local diets (van Huis *et al*., 2013). South Asia, including Pakistan, has comparatively limited traditional entomophagy practice and correspondingly strong cultural resistance to insect consumption as food, a pattern that has meaningfully slowed policy and market development relative to Southeast Asia even where the underlying agroecological potential is comparable. This acceptance barrier is real and should not be minimized, but international experience suggests it is more tractable when insects are introduced as processed ingredients, insect flour incorporated into familiar products such as bread or snack foods, rather than as whole, visually recognizable insects, and when introduction is paired with credible food-safety certification that addresses the (generally low but non-zero) allergenicity and contamination risks associated with insect products (Sogari *et al*., 2019).

4.3. Insect Farming for Animal Feed: A Lower-Barrier Entry Point

Where entomophagy faces a direct consumer acceptance barrier, insect-based animal feed faces a substantially lower one, since the insects are consumed by livestock, poultry, or farmed fish rather than by people directly, while still displacing conventional feed ingredients, chiefly fishmeal and soymeal, whose production carries its own food security and environmental costs. Black soldier fly (Hermetia illucens) larvae have emerged as the leading candidate species for feed applications because they can be reared on organic

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waste streams, including agricultural byproducts and food waste, converting a disposal cost into a protein input (Nyakeri *et al*., 2017). Given this volume's separate treatment of aquaculture as an underrepresented pillar of food security (Chapter 7), the connection is direct: insect-based feed represents one of the more promising pathways for reducing the fishmeal dependence that currently constrains the environmental and economic sustainability of aquaculture expansion in exactly the coastal developing economies that Chapter 7 examines.

4.4. The Regulatory Vacuum

The single largest constraint on the gain pathway in most developing economies, and in Pakistan specifically, is not biological, technical, or even primarily cultural, but regulatory. Novel food and feed regulatory frameworks capable of classifying insect species for human consumption or animal feed use, setting food-safety and contamination standards, and providing a licensing pathway for insect-farming enterprises are largely absent. The European Union's novel food regulation, which since 2021 has authorized several insect species for human consumption subject to specified safety assessments (EFSA, 2021), and Thailand's decades-long, informally regulated but increasingly formalized cricket-farming sector, now estimated to comprise tens of thousands of small-scale farms supplying both domestic and export markets (Hanboonsong *et al*., 2013), illustrate two different institutional pathways, formal ex ante regulation and gradual formalization of organic market development, by which the regulatory vacuum can be closed. Pakistan currently has neither.

4.5. Nutritional Comparison and the Scale-Up Question

The nutritional argument for insects as food and feed is strongest in comparative terms. On a dry-weight basis, many farmed edible insect species provide protein content comparable to beef and poultry, with crickets and mealworms typically falling in a range of roughly 45 to 65 grams of protein per 100 grams of dry matter, alongside favorable ratios of unsaturated to saturated fat and meaningful concentrations of iron, zinc, and vitamin B12, nutrients for which deficiency remains widespread among food-insecure populations in developing economies (van Huis *et al*., 2013). The resource case scales in the same direction: because insects are poikilothermic and exhibit high feed-conversion efficiency, farmed crickets have been estimated to require roughly twelve times less feed than cattle and roughly half the feed of poultry to produce an equivalent quantity of protein, with correspondingly lower land and water requirements (van Huis, 2013; Oonincx & de Boer, 2012). These figures should not be read as implying that insect farming can or should substitute wholesale for existing livestock systems, on which rural livelihoods and cultural practice depend; the more realistic and policy-relevant claim is narrower, that insect-based feed can displace a meaningful share of the fishmeal and soymeal currently imported or diverted from human-edible grain stocks, and that insect-based food ingredients can supplement, rather than replace, existing protein sources in nutritionally vulnerable populations, particularly where introduced as processed ingredients rather than whole insects, as noted above.

5. The Insect-Mediated Food Security Framework (IMFSF)

5.1. Framework Logic

This chapter proposes the Insect-Mediated Food Security Framework as an integrated model for assessing and governing the dual role of insects in national food security. The framework's central proposition is that the net food security contribution of insects in each country (NFSC) can be represented as:

NFSC = (Losses Avoided through the Loss Pathway) + (Value Captured through the Gain Pathway)

where both terms are functions of institutional quality rather than of insect biology or agroecological potential alone, which are comparatively fixed. The Loss Pathway is mediated by four institutional variables: surveillance and early-warning capacity, extension delivery, quarantine and cross-jurisdictional coordination, and input-market regulation. The Gain Pathway is mediated by four parallel institutional variables: novel food/feed regulatory capacity, research and development investment in rearing and

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processing technology, market and value-chain development, and public communication and acceptance-building capacity. A country with strong institutions on both sets of variables realizes low pest losses and high captured value from insect-based food and feed; a country weak on both, the Pakistani pattern documented in this chapter, realizes high losses and negligible captured value, representing the worst available combination on the underlying biological endowment. Critically, the framework predicts, and the Pakistani case illustrates, that the two pathways are not independent: the technical, surveillance, and extension capacity built for the Loss Pathway, entomological expertise, laboratory and diagnostic infrastructure, field networks, is substantially transferable to the Gain Pathway, meaning that investment in one need not compete with investment in the other and may in fact create shared institutional foundations.

5.2. Positioning within the Volume

The IMFSF is intended to occupy a position in this volume analogous to the Global Marine Food Security Index proposed in Chapter 7: both frameworks respond to a domain, marine food systems and insect-mediated food security respectively, that has been treated in the wider literature as a specialist subsector rather than integrated into mainstream food security assessment, and both argue that the domain's proper treatment requires an institutional rather than a purely technical or production-focused lens. Where GMFSI is constructed as a scored, multidimensional index suited to cross-country benchmarking, the IMFSF is deliberately framed as a diagnostic and planning framework rather than a numerical index, reflecting the earlier stage of data availability and institutional development in the insect-food-security domain; a natural extension of this chapter's contribution would be the future construction of a scored index once national-level data on pest losses, extension coverage, and insect-farming activity become more systematically available.

5.3. A Diagnostic Summary Table

Table 21.1 summarizes the eight institutional variables of the IMFSF and provides a qualitative rating of Pakistan's current status on each, drawn from the diagnosis developed in Section 6. The table is intended as a diagnostic and planning tool rather than a scored index; assigning numerical weights to these variables in a way that supports cross-country comparison is identified in Section 5.2 as a priority for future research.

Table 21.1: IMFSF Institutional Variables: Qualitative Diagnosis for Pakistan

Pathway	Institutional Variable	Current Status in Pakistan
Loss	Surveillance and early-warning capacity	Weak; event-driven rather than continuous
Loss	Extension delivery	Weak; low IPM-trained extension worker-to-farmer ratio
Loss	Quarantine and cross-jurisdictional coordination	Fragmented; federal-provincial mandate overlap
Loss	Input-market regulation	Weak; counterfeit and substandard pesticide circulation
Gain	Novel food/feed regulatory capacity	Absent; no regulatory category exists
Gain	R&D investment in rearing/processing	Minimal; negligible relative to livestock research
Gain	Market and value-chain development	Absent; no organized insect-feed supply chain
Gain	Public communication and acceptance-building	Absent from extension and nutrition programming

6. Case Study: Pakistan through the IMFSF Lens

6.1. Loss Pathway Diagnosis

Applying the framework's four Loss Pathway variables to Pakistan yields a consistent diagnosis. Surveillance and early-warning capacity is event-driven rather than continuous, as the 2019–2020 locust emergency

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illustrated, with staffing and funding for the Department of Plant Protection contracting during non-crisis periods. Extension delivery is thin relative to farmer population, with agricultural extension worker-to-farmer ratios well below recommended levels in most provinces, and IPM-specific training reaching a small minority of smallholders. Quarantine and cross-jurisdictional coordination is complicated by the division of agricultural authority between federal and provincial governments following the Eighteenth Constitutional Amendment, a devolution dynamic examined in general terms in Chapter 5, which in the plant protection domain has produced exactly the risk pattern that chapter identifies: unfunded provincial mandates, fragmented reporting, and uneven capacity across provinces without the matched finance and national minimum standards needed for devolution to function well. Input-market regulation of the pesticide retail trade remains weak, with counterfeit and substandard product circulation documented by industry and government sources alike, reinforcing farmer overreliance on calendar-based spraying (Figure 21.1).

6.2. Gain Pathway Diagnosis

The Gain Pathway diagnosis is, if anything, starker. Pakistan has no novel food or feed regulatory category for insect products, meaning that any prospective insect-farming enterprise faces not a burdensome approval process but an absent one, a governance gap rather than a governance obstacle. Public and private research and development investment in insect rearing and processing technology is minimal relative to the scale of agricultural research investment directed at conventional livestock and crop breeding. Market and value-chain infrastructure for insect-based feed ingredients, which would allow black soldier fly or similar operations to sell into Pakistan's substantial poultry and aquaculture feed markets, does not exist in organized form. Public communication and acceptance-building efforts around entomophagy or insect-based feed are essentially absent from agricultural extension and nutrition programming (Figure 1).

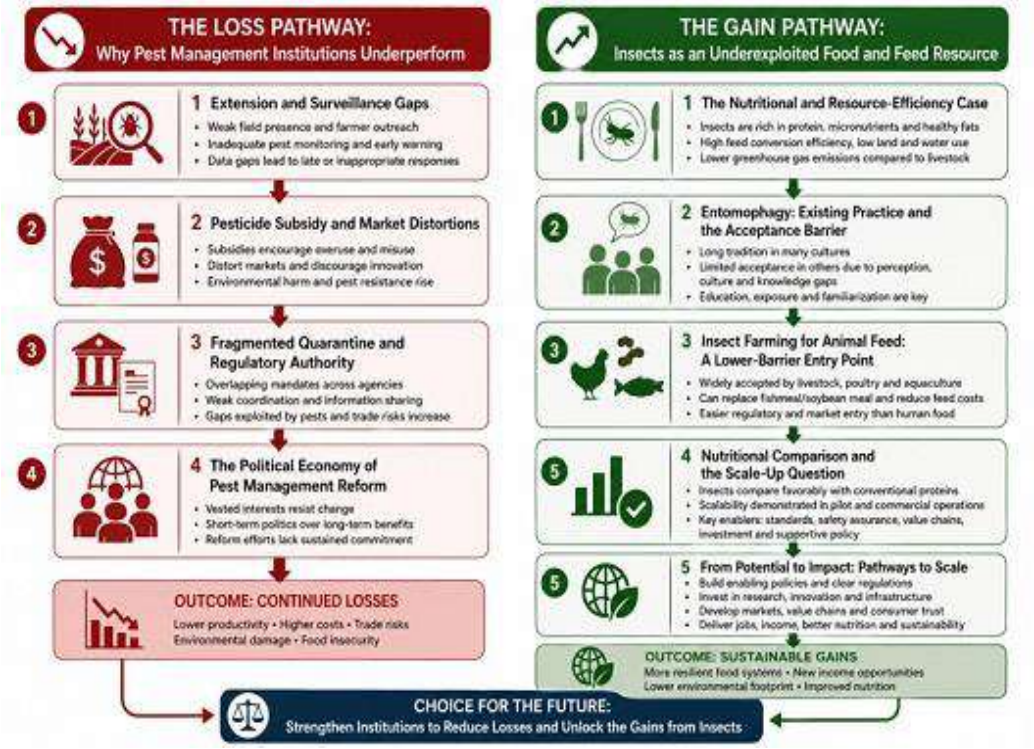
THE LOSS PATHWAY:
Why Pest Management Institutions Underperform
1 Extension and Surveillance Gaps
• Weak field presence and farmer outreach
• Inadequate pest monitoring and early warning
• Data gaps lead to late or inappropriate responses
2 Pesticide Subsidy and Market Distortions
• Subsidies encourage overuse and misuse
• Distort markets and discourage innovation
• Environmental harm and pest resistance rise
3 Fragmented Quarantine and Regulatory Authority
• Overlapping mandates across agencies
• Weak coordination and information sharing
• Gaps exploited by pests and trade risks increase
4 The Political Economy of Pest Management Reform
• Vested interests resist change
• Short-term politics over long-term benefits
• Reform efforts lack sustained commitment
OUTCOME: CONTINUED LOSSES
Lower productivity • Higher costs • Trade risks
Environmental damage • Food insecurity
THE GAIN PATHWAY:
Insects as an Underexploited Food and Feed Resource
1 The Nutritional and Resource-Efficiency Case
• Insects are rich in protein, micronutrients and healthy fats
• High feed conversion efficiency, low land and water use
• Lower greenhouse gas emissions compared to livestock
2 Entomophagy: Existing Practice and the Acceptance Barrier
• Long tradition in many cultures
• Limited acceptance in others due to perception, culture and knowledge gaps
• Education, exposure and familiarization are key
3 Insect Farming for Animal Feed: A Lower-Barrier Entry Point
• Widely accepted by livestock, poultry and aquaculture
• Can replace fishmeal/soybean meal and reduce feed costs
• Easier regulatory and market entry than human food
4 Nutritional Comparison and the Scale-Up Question
• Insects compare favorably with conventional proteins
• Scalability demonstrated in pilot and commercial operations
• Key enablers: standards, safety assurance, value chains, investment and supportive policy
5 From Potential to Impact: Pathways to Scale
• Build enabling policies and clear regulations
• Invest in research, innovation and infrastructure
• Develop markets, value chains and consumer trust
• Deliver jobs, income, better nutrition and sustainability
OUTCOME: SUSTAINABLE GAINS
More resilient food systems • New income opportunities
Lower environmental footprint • Improved nutrition
CHOICE FOR THE FUTURE:
Strengthen Institutions to Reduce Losses and Unlock the Gains from Insects

Figure 21.1: Depiction of Gain and Loss Pathways

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6.3. Institutional Failure Typology

Read against the four-type institutional failure typology developed in Chapter 4 for Pakistani food security governance more broadly, design failure, coordination failure, accountability failure, and adaptive failure, the insect-mediated food security case exhibits all four in recognizable form. Design failure is visible in the absence of any regulatory category for insect food and feed products, a gap that cannot be closed by better implementation because there is no policy design to implement. Coordination failure is visible in the federal-provincial fragmentation of plant protection authority documented above. Accountability failure is visible in the recurring pattern of crisis-driven emergency response followed by disinvestment once the immediate threat recedes, with no institutional mechanism holding surveillance capacity to a consistent standard between crises. Adaptive failure is visible in the persistence of calendar-based pesticide application and the absence of any systematic effort to evaluate or scale successful pilot IPM or insect-farming interventions into national policy, mirroring the broader adaptive-policymaking deficit that Chapter 16 identifies as a cross-cutting weakness in the region's food security governance.

6.4. Illustrative Economic Magnitudes

While a comprehensive national accounting of insect-mediated gains and losses for Pakistan does not currently exist, precisely because the surveillance and market-data systems that would generate such an accounting are among the institutional gaps this chapter identifies, illustrative magnitudes from adjacent, better-documented cases suggest the scale of what is at stake. The 2019–2020 locust emergency alone prompted government and donor estimates of potential agricultural and economic losses running into billions of dollars had the upsurge not been contained (Government of Pakistan, 2020), a single-event cost of the same order of magnitude as several years of Pakistan's total public agricultural research spending. On the Gain Pathway side, Thailand's cricket-farming sector, developed from a negligible base over roughly three decades, now generates estimated annual farm-gate revenue in the tens of millions of dollars and supports tens of thousands of largely rural, smallholder-operated farms (Hanboonsong *et al*., 2013), a scale that, while modest relative to Thailand's overall agricultural economy, represents exactly the kind of diversified, land-light rural income source that food security and rural livelihoods policy in Pakistan's own resource-constrained provinces could plausibly target. The asymmetry between a well-documented, single-event loss on one side of the ledger and an essentially undocumented, foregone opportunity on the other is itself a symptom of the institutional gap this chapter describes: what is measured tends to be managed, and Pakistan currently measures its insect-mediated losses, imperfectly, while not measuring its insect-mediated opportunities at all.

7. Comparative Evidence: What Functional Institutions Achieve

Three comparative cases illustrate that the institutional weaknesses documented in Pakistan are not inevitable features of developing-economy governance. Thailand's cricket-farming sector developed over several decades from informal household-level practice into a semi-formalized industry, now estimated at tens of thousands of farms, through a combination of extension support from Thai universities and the Department of Agriculture, gradual market formalization, and eventual engagement with export-oriented food-safety standards, illustrating a Gain Pathway development trajectory that required sustained institutional attention but not, initially, comprehensive ex ante regulation (Hanboonsong *et al*., 2013). Kenya's fall armyworm response, discussed in Section 3.4, illustrates a comparatively effective Loss Pathway response built on pre-existing plant health surveillance infrastructure rather than infrastructure created de novo during the emergency itself, underscoring the value of continuous rather than crisis-triggered institutional capacity. The European Union's novel food regulatory pathway for insect products, while developed under very different administrative and resource conditions than apply in most developing economies, nonetheless demonstrates the essential design elements, species-specific safety assessment, defined licensing procedures, and labeling requirements, that a developing-economy regulatory framework would need to adapt rather than replicate wholesale (EFSA, 2021).

Beyond these three primary cases, several smaller scale but instructive examples reinforce the pattern. Rwanda's post-genocide reconstruction of agricultural extension services, credited elsewhere in the

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comparative food security literature with above-average policy coherence and institutional capacity (Chapter 15), has also supported comparatively rapid farmer uptake of biological control and reduced-pesticide approaches for banana and cassava pests, suggesting that the general extension-system strength documented for Rwanda in other domains carries over into pest management specifically. Uganda and Kenya's parallel, university-linked pilot programs on black soldier fly rearing for poultry and aquaculture feed, though still small in absolute scale, have benefited from a comparatively receptive regulatory environment for novel feed ingredients relative to Pakistan's regulatory vacuum, allowing pilot-stage enterprises to progress toward commercial operation rather than remaining permanently confined to research settings. None of these cases represents a fully solved system; each retains its own institutional weaknesses. But taken together they demonstrate that the specific combination of continuous surveillance funding, extension systems capable of carrying new practices to farmer level, and a minimally functional regulatory pathway for novel food and feed products, is an achievable institutional configuration under developing-economy resource constraints, not a standard that only high-income countries can meet.

8. Policy and Governance Recommendations

Consistent with this volume's emphasis on politically feasible, sequenced reform rather than comprehensive but unrealistic policy prescriptions, five recommendations are proposed, ordered from lower to higher institutional and fiscal demand.

First, convert locust and fall armyworm surveillance from an emergency-triggered to a continuously funded function, with a protected budget line insulated from the funding volatility that has historically characterized Pakistan's plant protection spending. This is the lowest-cost, highest-return recommendation given the demonstrated cost of the alternative during the 2019–2021 upsurge.

Second, establish a functioning novel food and feed regulatory pathway for insect products, drawing on the European Union's framework for its technical design elements while calibrating approval requirements to Pakistan's institutional capacity, an initial focus on feed-grade applications, which carry lower food-safety stakes than direct human consumption, would allow the regulatory system to develop experience and credibility before extending to human food products.

Third, integrate IPM training into mainstream agricultural extension delivery, rather than treating it as a supplementary program dependent on donor project funding, and pair this with stronger enforcement of pesticide retail standards to reduce the counterfeit and substandard product circulation that currently undermines farmer trust in reduced-spray approaches.

Fourth, resolve federal-provincial coordination gaps in plant quarantine and pest surveillance authority through the kind of matched-finance, minimum-standards approach to decentralization recommended in Chapter 5, rather than through further ad hoc reassignment of responsibility without corresponding resources.

Fifth, direct a modest, ring-fenced allocation of agricultural research funding toward insect rearing, processing, and feed-substitution research, recognizing that the entomological and diagnostic capacity this requires substantially overlaps with the capacity needed to strengthen the Loss Pathway, meaning the marginal institutional cost of this investment is lower than a green-field research program would suggest.

These five recommendations are deliberately sequenced rather than presented as a simultaneous reform package, consistent with the political-economy realism this volume applies elsewhere to subsidy and price-control reform (Chapter 6): the first and third recommendations require reallocation of existing budgets and administrative attention rather than new legislation, and could plausibly be implemented within a single budget cycle; the second and fourth require legislative or intergovernmental coordination and should be treated as medium-term objectives; the fifth is contingent on demonstrated success in the earlier steps and on the availability of fiscal space within the broader agricultural research budget. A useful institutional entry point for several of these recommendations already exists in Pakistan's provincial agricultural universities and the Pakistan Agricultural Research Council, whose entomology departments possess much of the diagnostic and rearing expertise the Gain Pathway requires, but whose research agendas remain

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overwhelmingly oriented toward conventional crop protection rather than insect-based food and feed applications, a reorientation that would not require new institutions so much as a redirected mandate and a small, dedicated funding stream.

8.1. Implications for Future Research

Three research priorities follow directly from the diagnostic and framework contributions of this chapter. The first is the systematic collection of national-level data on insect-mediated pre-harvest and postharvest losses disaggregated by crop, region, and pest species, without which the Loss Pathway component of the IMFSF cannot be quantified with confidence and against which the return on surveillance and extension investment cannot be evaluated. The second is applied research on the technical and economic feasibility of insect-based feed substitution specifically calibrated to Pakistan's poultry and aquaculture sectors, given that the resource-efficiency case reviewed in Section 4 is drawn substantially from research conducted in other agroecological and market contexts. The third, and most directly aligned with this volume's broader methodological orientation, is the extension of the IMFSF from a qualitative diagnostic tool into a scored, cross-country index, following the analytical path Chapter 7 has already charted for marine food systems, once sufficient countries have developed the underlying loss and value-capture data this chapter finds largely absent even in Pakistan's case.

9. Conclusion

Insects will remain a permanent feature of developing-economy food systems; the open question this chapter has addressed is not whether they matter for food security, but which of their two faces, destructive or productive, a given country's institutions allow to predominate. The evidence assembled here, from the 2019–2021 desert locust upsurge to the continuing absence of any regulatory pathway for insect-based food and feed in Pakistan, indicates that the country currently captures the worst of both possibilities: substantial, recurring, and only partially institutionally contained losses on one side, and a wholly uncaptured resource opportunity on the other. Consistent with the volume's central argument, closing this gap does not primarily require new entomological science, the relevant pest management and insect-rearing technologies are, for the most part, already established internationally, but new institutional capacity: continuous rather than crisis-driven surveillance, coordinated rather than fragmented quarantine authority, and a regulatory foundation for insect-based food and feed that currently does not exist. The Insect-Mediated Food Security Framework developed in this chapter is offered as a starting point for that institutional agenda, and as an invitation to future research to extend it into a scored, cross-country index as the underlying data infrastructure matures.

References

Affognon, H., Mutungi, C., Sanginga, P., & Borgemeister, C. (2015). Unpacking postharvest losses in sub-Saharan Africa: A meta-analysis. *World Development*, 66, 49–68. https://doi.org/10.1016/j.worlddev.2014.08.002

APHLIS. (2021). *African postharvest losses information system: Postharvest loss estimates*. African Postharvest Losses Information System. https://www.aphlis.net

Brar, S. & Bhullar, H.S. (2022). Assessment of yield losses due to sucking pests in Bt cotton. *Indian Journal of Entomology, e21127. https://doi.org/10.55446/IJE.2022.158*

Day, R., Abrahams, P., Bateman, M., Beale, T., Clottey, V., Cock, M., Colmenarez, Y., Corniani, N., Early, R., Godwin, J., Gomez, J., Moreno, P. G., Murphy, S. T., Oppong-Mensah, B., Phiri, N., Pratt, C., Silvestri, S., & Witt, A. (2017). Fall armyworm: Impacts and implications for Africa. *Outlooks on Pest Management*, 28(5), 196–201. https://doi.org/10.1564/v28_oct_02

Deutsch, C. A., Tewksbury, J. J., Tigchelaar, M., Battisti, D. S., Merrill, S. C., Huey, R. B., & Naylor, R. L. (2018). Increase in crop losses to insect pests in a warming climate. *Science*, 361(6405), 916–919. https://doi.org/10.1126/science.aat3466

EFSA Panel on Nutrition, Novel Foods and Food Allergens. (2021). Safety of dried yellow mealworm (Tenebrio molitor larva) as a novel food pursuant to Regulation (EU) 2015/2283. *EFSA Journal*, 19(1), e06343. https://doi.org/10.2903/j.efsa.2021.6343

FAO. (2019). *Briefing note on FAO actions on fall armyworm*. Food and Agriculture Organization of the United Nations. https://www.fao.org/fall-armyworm/en/

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FAO. (2021). *Desert locust upsurge: Progress report on the response in the Greater Horn of Africa and Yemen*. Food and Agriculture Organization of the United Nations. https://openknowledge.fao.org/handle/20.500.14283/cb7161en

Goergen, G., Kumar, P. L., Sankung, S. B., Togola, A., & Tamò, M. (2016). First report of outbreaks of the fall armyworm Spodoptera frugiperda (J E Smith) (Lepidoptera, Noctuidae), a new alien invasive pest in West and Central Africa. *PLOS ONE*, 11(10), e0165632. https://doi.org/10.1371/journal.pone.0165632

Government of Pakistan. (2020). *National action plan for locust control 2020*. Ministry of National Food Security and Research. https://mnfsr.gov.pk/SiteImage/Misc/files/JD%20Social%20Development%20and%20Environment%20Specialists.pdf

Hameed, S., Khalid, S., Ehsan-ul-Haq & Hashrni, A. A. (1993). Cotton leaf curl disease in Pakistan caused by a whitefly-transmitted geminivirus. *Plant Diseases,* 78:529. https://doi.org/10.1094/PD-78-0529H

Hanboonsong, Y., Jamjanya, T., & Durst, P. B. (2013). *Six-legged livestock: Edible insect farming, collecting and marketing in Thailand*. FAO Regional Office for Asia and the Pacific. https://www.fao.org/4/i3246e/i3246e.pdf

Nawaz, B., Naeem, M., Ahmad M.T., Muhae-Ud-Din, G., Ahmad, Q., & Sattar, S. (2019). A review about cotton leaf curl viral disease and its control strategies in Pakistan. *International Journal of Innovative Approaches in Agricultural Research*, 3(1), 132-147. https://doi.org/10.29329/ijiaar.2019.188.13

Nyakeri, E. M., Ogola, H. J., Ayieko, M. A., & Amimo, F. A. (2017). Valorisation of organic waste material: Growth performance of wild black soldier fly larvae (*Hermetia illucens*) reared on different organic wastes. *Journal of Insects as Food and Feed*, 3(3), 193–202. https://doi.org/10.3920/JIFF2017.0004

Oerke, E. C. (2006). Crop losses to pests. *The Journal of Agricultural Science*, 144(1), 31–43. https://doi.org/10.1017/S0021859605005708

Olson, M. (1965). *The logic of collective action: Public goods and the theory of groups*. Harvard University Press.

Oonincx, D. G. A. B., & de Boer, I. J. M. (2012). Environmental impact of the production of mealworms as a protein source for humans: A life cycle assessment. *PLOS ONE*, 7(12), e51145. https://doi.org/10.1371/journal.pone.0051145

Parsa, S., Morse, S., Bonifacio, A., Chancellor, T. C. B., Condori, B., Crespo-Pérez, V., Hobbs, S. L. A., Kroschel, J., Ba, M. N., Rebaudo, F., Sherwood, S. G., Vanek, S. J., Faye, E., Herrera, M. A., & Dangles, O. (2014). Obstacles to integrated pest management adoption in developing countries. *Proceedings of the National Academy of Sciences*, 111(10), 3889–3894. https://doi.org/10.1073/pnas.1312693111

Savary, S., Willocquet, L., Pethybridge, S. J., Esker, P., McRoberts, N., & Nelson, A. (2019). The global burden of pathogens and pests on major food crops. *Nature Ecology & Evolution*, 3(3), 430–439. https://doi.org/10.1038/s41559-018-0793-y

Sogari, G., Menozzi, D., & Mora, C. (2019). The food neophobia scale and young adults' intention to eat insect products. *International Journal of Consumer Studies*, 43(1), 68–76. https://doi.org/10.1111/ijcs.12485

van Huis, A. (2013). Potential of insects as food and feed in assuring food security. *Annual Review of Entomology*, 58, 563–583. https://doi.org/10.1146/annurev-ento-120811-153704

van Huis, A., Van Itterbeeck, J., Klunder, H., Mertens, E., Halloran, A., Muir, G., & Vantomme, P. (2013). *Edible insects: Future prospects for food and feed security*. Food and Agriculture Organization of the United Nations. https://www.fao.org/4/i3253e/i3253e.pdf

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CHAPTER 22

Comparative Policy Performance Across South Asia, Sub-Saharan Africa, and the Middle East & North Africa (MENA): Institutional Diversity, Cross-Regional Lessons, and Transferable Innovations

Muhammad Hafeez[1], Ahras Rashid[1,*], Burhan Ahmad[1] & Muhammad Amjed Iqbal[2]
[1]Institute of Business Management Sciences, University of Agriculture, Faisalabad, Pakistan
[2]Institute of Agricultural & Resource Economics, University of Agriculture, Faisalabad, Pakistan
Corresponding Author: ahras_rashid@uaf.edu.pk

Abstract

Institutional quality plays a decisive role in shaping policy performance and development outcomes across regions with diverse political, administrative, and socioeconomic contexts. This chapter examines governance systems in South Asia, Sub-Saharan Africa, and the Middle East and North Africa (MENA) to understand how institutional structures influence policy effectiveness and identify transferable policy innovations. Drawing on Institutional Theory and the Worldwide Governance Indicators framework, the analysis evaluates six governance dimensions: voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption. The chapter demonstrates that policy success depends not only on sound design but also on institutional capacity, governance quality, and adaptation to local contexts. While South Asia benefits from democratic participation and digital transformation, Sub-Saharan Africa exhibits strong innovation despite institutional constraints, and MENA leverages centralized planning and state capacity for long-term development. The comparative analysis reveals that no single governance model is universally applicable; instead, effective policy transfer requires institutional compatibility, stakeholder participation, and context-specific adaptation. The chapter concludes by presenting cross-regional lessons that emphasize strengthening governance, administrative capacity, transparency, and digital innovation as essential foundations for sustainable development and improved public policy performance in developing regions.

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1. Introduction

South Asia includes many of the world's fastest growing nations (e.g., Pakistan, India, Bangladesh, Sri Lanka, Nepal, Bhutan, and the Maldives) (World Bank, 2025). The combination of rapidly developing digital democracies and civil societies, coupled with emerging markets, creates a governance framework with both great potential and significant challenges. Persistent issues such as extreme poverty, widespread unemployment, bureaucratic inertia, heightened political and regional disparities, climate change, and large informal economies are part of the complex system that makes South Asia a relevant region to study the role of democratic engagement, decentralization, and technology-based governance innovations in improving policy and governance constructs supported by adaptive and functional institutional frameworks. Though Sub Saharan Africa has regions with varying levels of institutional flexibility and state capacity, civil stability and modern administration, and sustained economic activity, it also has a diverse range of flexible institutional frameworks within resource constrained context countries such as Rwanda, Kenya, Ghana, Nigeria, and Ethiopia. With inadequate infrastructure and a highly dependent donor environment, some of the less stable countries also maintain innovative frameworks for administrative management (Acemoglu & Robinson, 2012). Sub Saharan Africa has the varied contexts needed to study the flexibility of innovations within highly resource constrained and uneven contexts.

The countries of the Middle East and North Africa (MENA), which include Saudi Arabia, the United Arab Emirates, Morocco, Egypt, Jordan, Tunisia, and Algeria, apply a variety of similar strategies to enhance the economic development of Gulf countries. These strategies include long-term, national infrastructure

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investments guided by an explicit Central Planning document. Examples of such plans include Saudi Vision 2030, the UAE Centennial 2071, and policy reforms in Morocco related to its renewable energy and agriculture. MENA has the planning, public investments, and the rapid digital infrastructure to convert plans to action. However, youth unemployment, the need for economic diversification, water scarcity, political unrest, and calls for reform of the governing bodies also challenge MENA. MENA provides an example of how state-led development has accelerated the economy and modernization; however, MENA also shows that there is a need for inclusive institutions to sustain the modernization.

In summary, South Asia, Sub-Saharan Africa, and MENA provide a valuable framework for comparing institutions and assessing the performance of various policies. The diverse political systems, administrative frameworks, histories of resource endowment, and patterns of development differentiate the three regions. However, they share common governance challenges and concerns in public service delivery, social inclusion, economic resilience, and sustainable development. This chapter aims to highlight the variations in these regional governance contexts, evaluate how the quality of governance in each context influences policy, disseminate policy innovations with a high degree of transferability, and address the regional gap in sustainable development through an enhancement in the quality of governance.

1.1. Purpose of the Chapter

This chapter aims to examine how institutional structures influence policy performance across South Asia, Sub-Saharan Africa, and MENA. It compares governance systems, administrative capacity, political environments, regulatory quality, and citizen participation mechanisms to understand why some policies perform better than others. The chapter also identifies policy innovations that have produced positive outcomes and considers whether these innovations can be adapted across regions. The overall purpose is to build a comparative understanding of institutional diversity and to provide policy-relevant lessons for strengthening governance and development performance.

1.2. Research Questions

1. How do institutional structures influence policy performance across South Asia, Sub-Saharan Africa, and MENA?

2. Which policy innovations have demonstrated success in addressing development challenges?

2. Conceptual Framework

2.1. Institutions and Development:

Institutional Theory

Institutions can manifest as formal or informal arrangements, and they set the standards for the behaviors that are social, political, and economic. Institutional Theory posits that the design, execution, and results of policies are impacted by the law and by the social constructs of norms, values, and beliefs, and by the routines observed and practiced by organizations. In the field of development studies, this theory can show that the environment within which policies are executed can be as important or more important for the success of the policies than the financial and planning resources that are devoted to the policies (Scott, 2014; Rodrik, 2007).

According to Table 22.1, Institutional Theory consists of three closely related pillars. The regulatory pillar shows that development policies need legal frameworks and outlines how policies will be implemented and enforced. Where robust regulatory systems do not exist, well-structured policies may still be undermined by low compliance, corruption, and administrative delays. The normative pillar demonstrates that the social values, professional socialization, and the accountability expectations of public officials and citizens shape policy performance. If social norms that support transparency, participation, and norm-service delivery are in place, policy performance will be enhanced. The cultural-cognitive pillar shows that the beliefs and perceptions of the citizenry shape policy performance. Policies are likely to perform better when they align with local customs, the existing institutional framework, and the expectations of the

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citizenry. Therefore, Institutional Theory postulates that effective policy transfer cannot occur by simply transposing the policy of one country or region to another, but rather that policy transfer must consider the institutional framework of the receiving country or region.

Table 22.1: Institutional Theory

Pillar of Institutional Theory	Main Meaning	Policy Relevance	Examples of Developing Regions
Regulatory Pillar	Formal rules, laws, regulations, sanctions, and enforcement mechanisms.	Determines whether policies are legally supported, consistently implemented, and effectively monitored.	Tax laws, procurement rules, anti-corruption laws, environmental regulations, public sector reforms.
Normative Pillar	Values, ethical expectations, professional standards, and accepted social obligations.	Shapes legitimacy, public trust, administrative behaviour, and willingness to comply with policy decisions.	Civil service ethics, professional norms, community expectations, NGO participation, accountability culture.
Cultural-Cognitive Pillar	Shared beliefs, assumptions, traditions, and ways of understanding authority and development.	Influences how citizens, firms, and officials interpret reforms and whether innovations are accepted.	Attitudes toward government, digital adoption, social trust, cultural views on participation and authority.

2.2. Governance and Policy Performance

Governance is the way public power is exercised, decisions are made, resources are allocated, and responsibility is upheld. Policy performance represents the level to which government actions accomplish intended objectives of enhanced service delivery, reduction of poverty, growth in the economy, sustainability of the environment, and increased public trust (Kaufmann *et al*., 2011). The Worldwide Governance Indicators (WGI) associates six key dimensions of governance (World Bank, 2025; Kaufmann *et al*., 2011; Fukuyama, 2013). In conjunction with the governance framework and associated literature on institutional performance, these dimensions articulate why the same policies may have different results in various regions (Hafeez *et al*., 2020; Yasmeen *et al*., 2018)

Voice and Accountability

Voice and Accountability pertain to citizens' abilities to engage in government elections and opinion expression processes (World Bank, 2025; Kaufmann *et al*., 2011). This covers citizens' freedom of expression and association, media autonomy, and community involvement. Stronger voice and accountability provide better policy legitimacy, as citizens can raise issues and provide feedback. South Asia has strong electoral participation and civic engagement and, if not for polarization, would likely prove the strongest of the three regions discussed. SSA and MENA are characterized by extremely diverse and inconsistent levels of civic engagement based on the systems of governance and political liberalization in respective nations.

Political Stability

Political stability assesses extent of potential remaining stable governance and the absence of disruptions from violence, conflicts or alterations of governance through unconstitutional means (Kaufmann *et al*., 2011; Yasmeen *et al*., 2018). Certainly, the political environment needs stability to carry out and support long-term plans and their implementation. For example, multi-year continuity is required to develop the national vision, infrastructure, and education reform policies. Rwanda, the UAE, and Saudi Arabia illustrate the effect of stable planning environments on strategic reforms. However, stability needs to be paired with inclusion to avoid the situation where long-term development occurs without social participation.

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Government Effectiveness

Government Effectiveness considers the quality of public services, the capacity of the civil service, and the formulation and implementation of public policy (Fukuyama, 2013; Yasmeen *et al*., 2018). Strong bureaucratic systems improve the delivery of health services and education, infrastructure, digital services, and social protection (Kaufmann *et al*., 2011). When government agencies are professional and coordinated, policy targets are more likely to be achieved. Effectiveness in South Asia is mixed and results from the uneven capacity of a large bureaucracy, while SSA is more variable by country. Due to centralized planning and investment, MENA Gulf states often show a stronger administrative capacity.

Regulatory Quality

Regulatory Quality relates to how well governments create and implement regulations that promote both the development of the private sector and the well-being of the public (Kaufmann *et al*., 2011; Yasmeen *et al*., 2018). Good regulations create a lower level of uncertainty and increase the amount of investment and innovation while protecting customers. Inadequate regulations increase the barriers entrepreneurs encounter and decrease the credibility of various policies. For business reform, good regulation design really creates a large impact, as shown by the business reform regulations of the UAE, the renewable energy regulations of Morocco, and the financial sector reforms in Ghana. For good policy transfer, regulations have to be simple and easily enacted while aligning with the capabilities of the locality.

Rule of Law

The Rule of Law demonstrates faith in various legal and justice institutions as well as their enforcement mechanisms (World Bank, 2025; Kaufmann *et al*., 2011). A robust Rule of Law fosters public and private investment, and trust in public institutions, while minimizing conflicts within civil society (Yasmeen *et al*., 2018). Businesses and individuals are likely to cooperate with public policy when they perceive law to be applied justly and uniformly. Where the Rule of Law is weak, civil life is plagued by insecurity and domination by a small elite, and law is applied selectively. In all three regions, addressing the efficiency and predictability of the courts and law is crucial to achieve the necessary policy objectives.

Control of Corruption

Control of Corruption assesses the degree to which public power is exercised for the public good rather than private gain (Kaufmann *et al*., 2011). By diverting resources, increasing costs, reducing trust, and the quality of services provided, corruption undermines development. If combined with transparency and accountability, as well as digital systems and auditing, anti-corruption reforms enhance the implementation of policies. Leakage in public programs can be minimized by employing digital payments, e-procurement, biometric systems, and open data. Technology by itself, however, is insufficient and must be accompanied by enforcement as well as ethical and political dedication.

3. Institutional Contexts Across Regions

The regions of South Asia, Sub-Saharan Africa and the MENA region have drastically different governance and administrative systems, political systems and development priorities, and how these regions construct government systems impacts how policies, resources, and reforms are distributed, as well as how stakeholders are approached and engaged. Even though all three regions have similar development problems of improving economic growth and access to public services while building climate resilience and reducing poverty, these regions have developed different systems to address these problems. For policy performance, identifying potential opportunities for learning and transferring policy systems between the regions will require knowledge about the different strengths and challenges of the regions' various systems (Rodrik, 2007). Institutional Contexts in the Three Regions provides a summary of the three regions' systems.

The three regions' institutional foundations are illustrated in table 22.2. South Asia is typically deemed politically active and democratic with rapid digitalization, but slow policies and fragmented politics

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negatively impact their constructive engagement (Andrews, 2013). Technology and the financial sector help to improve health outcomes and women empowerment in Asia and South Asia, respectively (Jing *et al*., 2022; Hafeez *et al*., 2020). Sub-Saharan Africa is very heterogeneous. Some nations have successfully implemented reform, while others still grapple with conflict, lack of capacity, and fiscal constraints. MENA nations, especially the Gulf states, have highly developed state capacity and planning; however, the lack of participatory inclusiveness and the economies remaining concentrated are still issues of concern. By looking at these regions, it is clear that every model and every region have strengths. It is impossible to establish a model that fits perfectly everywhere. Each region has something to offer to the others. However, the efforts toward reforming must consider the situation of each locale, particularly the politics and the social and administrative patterns.

Table 22.2: Comparative Overview of the Institutional Contexts Across Regions

Region	Representative Countries	Governance Features	Institutional Strengths	Institutional Challenges
South Asia	Pakistan, India, Bangladesh, Sri Lanka, Nepal, Bhutan, Maldives	Most countries operate under democratic and parliamentary systems, with ongoing efforts to strengthen decentralization, improve public administration, and expand digital governance. Civil society organizations and citizen participation continue to play an important role in governance.	The region benefits from large and rapidly growing markets, a youthful population, expanding digital technologies, active civil society organizations, and increasing entrepreneurial activity, all of which support long-term development.	Many countries continue to face challenges related to bureaucratic delays, governance inefficiencies, corruption, political polarization, regional disparities in development, a large informal economy, and increasing vulnerability to climate change.
Sub-Saharan Africa	Rwanda, Kenya, Ghana, Nigeria, Ethiopia, Tanzania, South Africa	Governance systems vary across countries, ranging from centralized to decentralized structures. Many governments have introduced public sector reforms, while regional organizations and international development partners continue to influence governance and institutional development.	The region has demonstrated strong innovation in mobile technology and digital finance, growing entrepreneurial ecosystems, successful community-driven development initiatives, policy experimentation, and increasing regional cooperation.	Despite progress, several countries continue to experience infrastructure deficits, limited fiscal capacity, uneven institutional performance, political instability in some areas, and varying levels of dependence on external donor support.
MENA	Saudi Arabia, UAE, Morocco, Egypt, Jordan, Tunisia, Algeria	Governance is generally characterized by a strong public sector and centralized planning, supported by long-term national development strategies, economic diversification programs, and significant investments in strategic infrastructure.	Many countries possess strong state institutions, well-developed infrastructure, ambitious long-term development visions, expanding digital government initiatives, and substantial public investment capacity, particularly among the Gulf states.	The region continues to address persistent issues such as high youth unemployment, water scarcity, the need for greater economic diversification, varying levels of public participation in governance, and ongoing political and geopolitical tensions.

4. Comparative Governance Analysis

A comparative governance analysis accounts for the impact of institutional differences on the variation of policy outcomes (Fukuyama, 2013; North, 1990). The following table highlights the core institutional traits,

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advantages, disadvantages, and policy considerations for each of the three regions. Table 22.3 shows the differences present in the varying governance models across the different regions. In South Asia, the democratic structures initiate potential for the public to hold officials accountable; however, political rivalry can obstruct the reforms for a time. Sub-Saharan Africa demonstrates the widest difference in governance models as countries have unique levels of stability, administrative capability, and maturation of their governance structures. Countries in MENA most likely rely on centralized governance as it allows pathways to rapidly implemented planning of infrastructural, digital, and economic changes. Centralized governance structures may also require more participatory mechanisms to gain legitimacy and responsiveness. Respectively, the different governance models will require varied mechanisms for public participation to ensure the efficacy of their structures.

Table 22.3: Main Institutional Characteristics, Strengths, Weaknesses, and Policy Implications Across Regions

Dimension	South Asia	Sub-Saharan Africa	MENA	Policy Implication
Governance Model	Mostly democratic and parliamentary	Mixed: democratic, hybrid, and centralized systems	Often centralized, especially in Gulf states	Policy design must match political authority structures and participation channels.
Administrative Capacity	Moderate but uneven across countries and sectors	Variable; strong in some countries and weak in others	Generally stronger in high-capacity Gulf states	Implementation depends on bureaucracy, coordination, and monitoring capacity.
Digital Transformation	High and expanding rapidly	Increasing through mobile and platform innovation	High, especially in smart government systems	Digital tools can improve service delivery when supported by inclusion and data governance.
Political Stability	Moderate with periodic instability	Highly variable across countries	Moderate to high in many Gulf states	Long-term policies require stability, but legitimacy also requires public trust.
Stakeholder Participation	Strong through elections, media, NGOs, and courts	Moderate and uneven; strong community models in some countries	Limited to moderate depending on country	Participation improves legitimacy, feedback, and policy sustainability.
State Capacity	Moderate; strong in some sectors, weak in others	Variable and often resource constrained	High in strategic planning and infrastructure	State capacity determines whether policy commitments become real outcomes.

Table 22.4 illustrates the specific combinations of relative strengths and weaknesses of each region (World Bank, 2025).

Table 22.4: Distinctive Combination of Strengths and Weaknesses for Each Region

Region	Major Institutional Strengths	Major Institutional Weaknesses	Policy Performance Effect
South Asia	Democracy, digitalization, civil society, large markets	Bureaucracy, political polarization, corruption, inequality	Strong policy ideas may face implementation delays unless coordination and accountability improve.
Sub-Saharan Africa	Mobile technology, innovation, community development, entrepreneurship	Capacity constraints, infrastructure deficits, fiscal weakness, instability in some states	Innovation can improve outcomes, but scale-up depends on state capacity and sustainable financing.

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MENA	State capacity, strategic planning, infrastructure, digital government	Limited participation in some countries, diversification pressures, water scarcity	Long-term visions can achieve rapid progress, but sustainability requires inclusion and institutional adaptability.

In South Asia, the main strengths are participatory governance and the expansion of the digital economy. However, policy implementation is more likely to be slow and fragmented due to the lack of structural integrity. In Sub-Saharan Africa, the main strengths are flexible, mobile, and community-based innovation; however, a lack of resources often restricts the sector's ability to scale. In the MENA region, a natural advantage of this region is a strong, goal-oriented state and planning; however, there are still central policy challenges of social inclusion, employment generation, and economic diversification. The central policy lesson is that the design of a policy is likely to be successful when matched with the capacity of the institutions.

5. Linking Institutions to Policy Performance (RQ1)

Institutions discourage or encourage policy performance as they impact decision-making and the allocation of resources, the capacity to implement, the accountability of the system, and trust by the public (North, 1990). Considered strong by most institutions reduce uncertainty by creating a predictable and stable system for citizens, corporations, and public agencies. Creating a predictable system is a major challenge for most public agencies. Weak institutions create gaps between the promises made by policy and the outcomes of policy. This section attempts to show the major institutional factors affecting the evaluation of performance in South Asia, Sub-Saharan Africa and MENA.

Of the factors affecting policy performance, government effectiveness is one of the most critical (Andrews, 2013). Countries that have professional civil service, coordinated ministries, and a reliable monitoring and evaluation system, as well as strong local governments, have a greater capacity to implement policy reforms. The performance-based governance system of Rwanda, the smart governance system of the United Arab Emirates, and the digital governance reforms of India, all demonstrate the impact of administrative capacity on the governance and service delivery. Fragmented or slow bureaucracies have significant impact on the ease of governance and the cost of implementation. Integration of financial sectors of Asia may uplift the cashflows, funds, to have sustainable renewable energy sources (Wang *et al*., 2025). In addition to the factors discussed, on the South African continent and in some Arab countries, a certain level of political stability has significant impact on the performance of most policies (Kaufmann *et al*., 2011). This is especially the case for the implementation of most modern infrastructure and climate projects, education reform, and economic diversification which require long-term commitments. United Arab Emirates Vision 2071, Saudi Vision 2030, and Rwanda Vision 2050 all evidence the impact of long-term policy commitments. However, political stability cannot be understood only as control, but as satisfying the legitimacy and inclusion of citizens, as well as responsiveness to citizens.

The inclusion of stakeholders in policymaking results in higher quality policies because citizens and businesses supply information to policymaking authorities that they otherwise would not know (World Bank, 2017). Networks of civil society in South Asia, the NGO sector in Bangladesh, local governance institutions in India, and community development models in Kenya demonstrate the benefits of participation in targeting and accountability. Policies that exclude stakeholders will face resistance to their adoption, and their sustainability will be weak. Participation, therefore, enhances both the legitimacy and the sustainability of policies.

The quality of regulation has a direct correlation to investment, entrepreneurship, environmental management, and innovation. Regulations that are clear and predictable reduce uncertainty and encourage investment. Business reforms in the UAE, reforms in the financial sector in Ghana, and renewable energy policies in Morocco show that regulation can foster development. In contrast, poor regulation increases informality, fosters a lack of investment, and creates a system of rent-seeking. Regulations need to be simplified, transparent, and applicable to the local context with the capacity for enforcement.

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The rule of law and the control of corruption also impact on the quality of policy. When public laws are justly enforced and corruption is controlled, there is a greater likelihood that public resources will be delivered to the intended beneficiaries. Digital governance innovations such as e-procurement, biometric verification, direct benefit transfers and faster online public services can reduce leakage and improve the transparency of the process. However, no innovation of this kind will supplant the need for legal enforcement and ethical public administration. Thus, reforms of this kind will need to be coupled with digital innovations and monitoring to ensure accountability and governance.

Overall, this demonstrates that institutions are not background conditions; they actively influence the success of policies. The same policy may yield different results across various regions due to the differences in institutional capacity, political stability, participation, regulation, legal systems, and control of corruption. This indicates that in policy transfer, the emphasis should be on learning and adaptation rather than direct copying. A successfully adopted innovation in one region should be modified to the recipient's administrative capacity, legal system, political environment, cultural characteristics, and available resources.

6. Conclusion

This chapter presents findings that show how the quality of institutions affects policy performance in South Asia, Sub-Saharan Africa, and MENA. South Asia is characterized by democracy, civil society, and decentralization, and has high potential from digital transformation, but has issues with bureaucratic inefficiency and political fragmentation. Sub-Saharan Africa has the issues of weak infrastructure, low administrative and fiscal capacity, with high potential from innovation, mobile technology, and entrepreneurship, as well as community-based development. MENA has issues of participation and youth employment, as well as the diversification of the economy and sustainable use of its resources, but has service state capacity, long-term planning with state investments in infrastructure and digital government, as well.

The analysis shows that the elements of governance such as voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption all have the potential to serve as a framework in the analysis of policy performance (Kaufmann *et al*., 2011). High performance in these areas boosts the efficiency of service delivery, increases the confidence in investments, and improves the social trust, as well as the sustainability of reforms. However, the success of development is not based on a single institutional model. It is the capacity of countries to introduce reforms based on their institutional context that determines success; therefore, the main conclusion of the chapter is that the innovations of policies that can be transferred have to be institutionally compatible, locally tailored, and provide accountable governance systems.

References

Acemoglu, D., & Robinson, J. A. (2012). *Why nations fail: The origins of power, prosperity, and poverty*. Crown Publishers.

Andrews, M. (2013). *The limits of institutional reform in development*. Cambridge University Press. https://doi.org/10.1017/CBO9781139060974

Fukuyama, F. (2013). What is governance? *Governance, 26*(3), 347–368. https://doi.org/10.1111/gove.12035

Hafeez, M., Andlib, Z., Naz, A., & Ullah, S. (2020). The impact of ICT on women empowerment: Evidence from selected South Asian countries. *NUST Journal of Social Sciences and Humanities, 6*(1), 45–61. https://doi.org/10.51732/njssh.v6i1.51

Jing, R., Ma, Y., Zhang, L., & Hafeez, M. (2022). Does financial technology improve health in Asian economies? *Frontiers in Public Health, 10*, Article 843379. https://doi.org/10.3389/fpubh.2022.843379

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2011). The Worldwide Governance Indicators: Methodology and analytical issues. *Hague Journal on the Rule of Law, 3*(2), 220–246. https://doi.org/10.1017/S1876404511200046

North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge University Press. https://doi.org/10.1017/CBO9780511808678

Rodrik, D. (2007). *One economics, many recipes: Globalization, institutions, and economic growth*. Princeton University Press.

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Scott, W. R. (2014). *Institutions and organizations: Ideas, interests, and identities* (4th ed.). Sage Publications.

Wang, L., Hafeez, M., Ullah, S., & Yonter, I. U. (2025). Cross-sectional dependence in financial openness and its influence on renewable energy consumption in Asia. *Energy & Environment, 36*(7), 3294–3315. https://doi.org/10.1177/0958305X231219786

World Bank. (2017). *World development report 2017: Governance and the law*. World Bank. https://www.worldbank.org/en/publication/wdr2017

World Bank. (2025). *Worldwide Governance Indicators (WGI)*. https://www.worldbank.org/en/publication/worldwide-governance-indicators

Yasmeen, R., Li, Y., Hafeez, M., & Ahmad, H. (2018). The trade-environment nexus in light of governance: A global perspective. *Environmental Science and Pollution Research, 25*(34), 34360–34379. https://doi.org/10.1007/s11356-018-3390-3

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CHAPTER 23

From Rethinking to Rebuilding: Answers, Implications, and the Road Ahead

Muhammad Khalid Bashir[1,2,*] & Muhammad Umar Farrukh[3]
[1]Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad, Pakistan
[2] Policy, Advocacy, and Outreach, Pak-Korea Nutrition Center, University of Agriculture, Faisalabad, Pakistan
[3]Department of Economics, Government College Women University, Sialkot, Pakistan
Corresponding author's email: khalid450@uaf.edu.pk

Abstract

This Conclusion synthesizes the arguments of the twenty-two preceding chapters, providing answers to each of the organizing questions posed in the Introduction. It derives ten practical implications for policymakers, NGOs, development practitioners, and researchers working on food security in developing economies. It acknowledges the limitations of the current volume and identifies five productive directions for future research. It closes with a statement of the volume's overall contribution to the literature on food security governance. The overriding conclusion is that food security in the twenty-first century is not primarily an agricultural problem: it is a governance problem. Solving it requires political commitment, institutional investment, evidence-based learning, and the willingness to treat food security as the political achievement it has always been.

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1. Answers to the Nineteen Organizing Questions

This volume opened with twenty-one questions. The twenty-two chapters provide answers analytically grounded, empirically supported, and honest about the limits of current knowledge.

Q1: Evolution of Food Security Policy (Chapter 2)

Food security policy has evolved across three recognizable phases, i.e. production-centric, access-and-distribution, and nutrition-sensitive/sustainable but each phase has left behind unresolved governance deficits that the next phase has struggled to overcome. The Green Revolution increased aggregate supply but marginalized smallholders and degraded ecosystems. The transition phase introduced social protection but generated leakage, targeting failures, and fiscal unsustainability. The current phase offers a more comprehensive framework but lacks the institutional capacity to deliver its ambitions on a scale. The fundamental finding is that no phase of food security policy has succeeded in translating superior design into effective delivery without strong, accountable, and adaptive institutions.

Q2: From Food Availability to Nutrition and Sustainable Food Systems (Chapter 3)

The pathways to nutrition security and environmental sustainability are well understood analytically: dietary diversification beyond staple calories; biofortification and precision agriculture to improve the nutritional content and resource efficiency of food production; smart aquaculture and integrated crop-livestock systems to diversify protein and micronutrient sources; and circular economy approaches to reduce food waste throughout the value chain. The barrier is not knowledge but incentive: the political economy of food systems consistently rewards cheap calorie production over nutritious food production, and the institutional architecture of food policy reinforces this bias. Aligning incentives with nutritional and environmental objectives requires deliberate policy redesign, not just technological innovation.

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Q3: Institutional Failures and Reform Pathways (Chapter 4)

Food security institutions in developing economies persistently fail to reach the most vulnerable because they are embedded in political systems that reward visible short-term transfers to organized constituencies over invisible long-term investments in governance capacity. The four-type typology, design failure, coordination failure, accountability failure, and adaptive failure, provides a diagnostic map for identifying which institutional pathologies are operating in any given context. The comparative evidence from Bangladesh, India, Brazil, and Ethiopia demonstrates that what distinguishes success from failure is not resource endowment or agricultural potential but the quality, coherence, and adaptability of institutions. Pakistan's governance deficit in food security is severe but not unique, and the multi-horizon reform pathway outlined in Chapter 4 from immediate coordination and digitization measures through medium-term R&D investment and land tenure reform to long-term constitutional clarity and climate-smart systems, is demanding but grounded in comparative precedent.

Q4: Decentralization and Local Food Governance (Chapter 5)

Decentralization strengthens food security governance when and only when it is designed as a coherent system matching devolved authority with predictable finance, administrative capacity, accountability mechanisms, and national minimum standards. Without these complementary elements, devolution displaces responsibility without redistributing capacity, producing fragmentation rather than responsiveness. The comparative evidence from six countries identifies fiscal scope as a necessary but far from sufficient condition: Brazil and India, with the highest subnational fiscal shares in the comparison group, have achieved significant food governance advances, but both have also experienced elite capture and territorial inequality that constrain outcomes for the most vulnerable. Effective decentralized food governance requires not just the transfer of functions but the construction of the entire governance system from national standards through provincial coordination to community accountability as an integrated architecture.

Q5: Political Economy of Subsidies, Procurement, and Price Controls (Chapter 6)

Economically inefficient food policy instruments persist because they are politically efficient: they deliver visible, concentrated, and immediate benefits to electorally important constituencies while diffusing their costs across taxpayers, future generations, and the poor in informal markets who never access the subsidized channels anyway. Fertilizer subsidies in India, bread subsidies in Egypt, wheat procurement in Pakistan, and cooking oil controls in Indonesia all display this pattern. The distributional incidence of these instruments is consistently more regressive than their nominal targeting implies. Reform is feasible, Brazil's Bolsa Família, India's Direct Benefit Transfer, and Indonesia's phased subsidy rationalization all demonstrate this, but requires a political strategy for managing the distributional coalition supporting the status quo, sequenced to protect the poor during transition and provide alternative income support to transitional losers before dismantling the instruments they depend on.

Q6: Marine Food Security (Chapter 7)

Marine food systems can and must be better integrated into national food security policy frameworks. The evidence from Indonesia, India, and Tanzania demonstrates that fisheries, aquaculture, and seaweed farming jointly support the livelihoods and nutrition of hundreds of millions of people in coastal developing economies, yet remain systematically underrepresented in food security assessments, governance frameworks, and academic research. The Global Marine Food Security Index (GMFSI) proposed in Chapter 7, integrating availability, accessibility, utilization, and sustainability dimensions alongside a Seaweed Security Sub-Index, provides the analytical architecture for correcting this blind spot. What is also needed is the political will to govern marine food systems as food security infrastructure rather than as an extractive resource, and to align fisheries management, sustainable aquaculture development, and seaweed promotion with national nutrition objectives. Indonesia's integration of seaweed into its Free Nutritious Meals Program is a model worth replicating.

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Q7: Food Price Volatility and Policy Responses (Chapter 8)

The primary drivers of food price volatility in developing economies with Pakistan as the primary case study include macroeconomic instability (inflation, exchange rate fluctuations, monetary policy changes), supply-side shocks (climate variability, crop failures), global market integration (which transmits international volatility to domestic markets), and structural market inefficiencies (fragmented supply chains, poor storage, regional price disparities). The welfare consequences for vulnerable households, particularly urban households spending more than half their income on food are severe and well-documented. The policy instruments that most effectively protect vulnerable populations without long-run market distortions are targeted social protection mechanisms, conditional cash transfers, food-specific vouchers, digital benefit delivery systems, rather than universal price controls or export bans. Building the institutional capacity for rapid, targeted social protection deployment is a higher-return investment than the market-distorting instruments that most developing country governments currently rely on.

Q8: Trade Policy, Export Bans, and Import Dependence (Chapter 9)

Export restrictions, import dependence, and asymmetric price transmission interact in South Asia to amplify food price volatility for food-importing countries and to depress farm-gate prices in food-exporting ones. India's 2023 non-basmati rice export ban affecting 40% of globally traded rice immediately raised international prices to their highest level in more than a decade, transmitting food insecurity from India's domestic political calculations to importing countries across Africa and Asia. The structural causes of South Asian import dependence, agricultural productivity gaps, inadequate rural infrastructure, climate vulnerability, and policy incoherence, cannot be addressed by trade policy alone. The governance architecture required is one that combines rules-based frameworks for when and how export restrictions can be applied, regional food reserve mechanisms that reduce the incentive for beggar-thy-neighbor trade policies, diversified import sourcing strategies, and domestic supply chain investment to reduce price shock pass-through.

Q9: Market Integration and Value Chain Governance (Chapter 10)

Road quality is the single strongest determinant of farm-gate prices in developing economy food chains ($\beta = 0.312$), outranking market information, quality standards, and contract arrangements in its contribution to price outcomes. Captive governance chains impose 38% consumer overpayment relative to competitive alternatives, representing a systematic welfare tax extracted through market power asymmetry. When infrastructure, information, and inclusive standards operate together under integrated governance, smallholder market participation rises from 22% to 74% and generates a causal price premium of 36%. The policy implication is clear: piecemeal interventions, a road project without accompanying market information, or a standards program without technical assistance, consistently underperform integrated governance reforms that address all three structural pillars simultaneously.

Q10: Climate Shocks and Food System Vulnerability (Chapter 11)

Climate shocks translate into food system vulnerability through multiple interacting pathways: directly by reducing crop yields, degrading soil fertility, disrupting water availability, and damaging post-harvest infrastructure; indirectly through food price volatility, rural income loss, and disrupted supply chains; and systematically through the disproportionate impact on smallholder farmers, women, rural populations, and coastal communities who have the least adaptive capacity and the greatest dependence on climate-sensitive livelihoods. The most effective integrated resilience strategies combine CRISPR-assisted crop varieties adapted to heat and salinity stress, biofertilizers and biopesticides to reduce input dependency, precision fermentation to diversify protein sources, AI-assisted early warning systems, and community-based adaptation processes that build on local knowledge and strengthen social capital.

Q11: Adaptive Food Security Policies under Climate Uncertainty (Chapter 12)

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Conventional static food security policies, premised on predictable climate and linear causal relationships, are structurally inadequate under the deep uncertainty that climate change imposes. Adaptive governance frameworks require three interlocking components: decision-making processes that use scenario-based planning, Robust Decision-Making, and trigger-based mechanisms to navigate incomplete information; learning systems that incorporate real-time monitoring, AI-assisted forecasting, and institutional feedback loops; and institutional agility that enables rapid resource mobilization, cross-sectoral coordination, and decentralized decision-making. Specific policy tools, dynamic food reserves, flexible subsidies, climate-indexed insurance, and scalable safety nets, must be designed to activate automatically when pre-agreed thresholds are crossed, removing the political lethargy and time lags that transform manageable food shocks into acute food crises.

Q12: Poverty, Inequality, and Food Access (Chapter 13)

Food insecurity is a structural outcome of intersecting inequalities rather than a temporary shortfall solvable by supply expansion. Asset inequality (particularly land concentration), gender inequality in resource access and decision-making power, spatial inequality (rural-urban divides, food deserts), institutional inequality (elite capture of subsidies and public procurement), and global trade governance failures (WTO agricultural negotiations stalled, export restrictions amplifying volatility) collectively reproduce food insecurity across generations. Transformative policy frameworks, rights-based food security legislation, pro-poor land reform, gender-sensitive agricultural extension, restructured social protection anchored in functional social registries, and reformed global trade governance, are required to address these root causes. Market efficiency frameworks that treat food insecurity as a temporary market failure to be corrected by productivity gains are analytically inadequate and historically discredited.

Q13: Food Security in Fragile and Conflict-Affected Contexts (Chapter 14)

In fragile and conflict-affected contexts, conventional food security policy frameworks collapse because they presuppose a functioning state, operational markets, and physical security, none of which can be taken for granted. The 2024 Global Report on Food Crises documented 295 million people in acute food insecurity, with conflict identified as the primary driver. The destruction of agricultural infrastructure, the collapse of supply chains, the use of food as a weapon, and the displacement of farming communities combined to undermine all four pillars of food security simultaneously. Resilience strategies in these contexts must hybridize humanitarian response with longer-term development objectives: community seed banks, mobile food assistance, cash transfers via mobile money, community-based early warning, and diplomatic efforts to protect humanitarian access. There is no purely technical solution to food insecurity in contexts where governance itself has failed; political solutions, conflict resolution, governance reconstruction, and the restoration of functioning institutions, are prerequisites for sustained food security progress.

Q14: Comparative Policy Lessons (Chapter 15)

Comparative evidence across developing economies confirms that identical policy instruments produce very different outcomes depending on institutional capacity, market conditions, and contextual constraints. The Framework Food System Outcomes = f(Policy Mix × Institutions × Incentives × Resources × Climate × Capacity) captures the key insight: policy effectiveness is conditional, not absolute. Five cross-cutting findings emerge: policy coherence matters enormously, as fragmented initiatives produce contradictory incentives; institutional capacity is the binding constraint, as even well-designed policies fail without capable implementing institutions; political economy factors shape both design and uptake; integrated approaches outperform sectoral interventions; and adaptive governance is essential under uncertainty. Context typology matters: high-capacity settings can implement complex integrated programs; low-capacity settings require simpler, more scalable interventions; climate-vulnerable settings need adaptive policies; fragile contexts require hybrid humanitarian-development approaches.

Q15: Adaptive and Evidence-Based Policymaking (Chapter 16)

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The IFPRI Kaleidoscope Model reveals that food security policy change depends on far more than technical merit: it requires the convergence of a politically recognized problem, a technically feasible solution, and a receptive political environment. Evidence alone does not drive policy change, evidence must be mediated through political economy dynamics, institutional channels, and learning mechanisms. The cases of Pakistan's Kissan Card (positive scaling through data infrastructure and political alignment), Brazil's CONSEA (institutional anchoring that survived multiple political transitions before being dismantled), China's provincial policy experimentation (systematic learning through managed variation), and Ethiopia's ATA (triple-loop learning through independent evaluation and course correction) demonstrate that durable food security policies are those embedded in institutions capable of double and triple-loop learning, continuously questioning not just implementation efficiency but strategic objectives and knowledge systems themselves.

Q16: Digital Tools, Data Systems and AI (Chapter 17)

Remote sensing, AI, big data, and predictive modelling have genuinely transformative potential for food security monitoring, early warning, and policy design: satellite crop monitoring achieves 82% crop identification accuracy with yield estimates within 5% of FAO benchmarks; AI systems can predict food security scenarios and generate real-time risk assessments; and digitally connected governance systems have raised crop yields by 10–30% in field trials. But this potential is systematically constrained by governance and equity failures: a persistent digital divide means most food-insecure populations remain invisible to AI-based assessment systems; crop monitoring algorithms are frequently not available for independent review; and most AI food security research is produced by Global North institutions about Global South populations without meaningful co-construction. Equitable digital governance requires data sovereignty frameworks, inclusive design processes, algorithmic accountability standards, and investment in local research capacity as preconditions for translating technological capability into policy impact.

Q17: Aligning Food Security with SDGs and Climate Commitments (Chapter 18)

Developing economies face a dual imperative: their food systems are among the most vulnerable to climate change, and their agriculture sectors are themselves significant contributors to greenhouse gas emissions. Meaningful SDG-climate alignment requires moving beyond the separate tracks of food security policy and climate policy to an integrated framework in which climate-smart agriculture, agroforestry, sustainable land management, food loss and waste reduction, and inclusive value chain development are simultaneously advancing SDG 2, SDG 13, and related goals. Over 90% of developing nations include agriculture in their NDCs; the gap is between commitment and implementation, driven by institutional fragmentation, inadequate financing, and weak inter-ministerial coordination. The Paris Agreement's recognition of the food production-climate change nexus is a policy that developing economies should leverage to access Green Climate Fund resources for integrated agri-climate investment programs.

Q18: National Food Security Transformation in South Asia (Chapter 19)

Long-run time-series analysis of Pakistan, India, and Bangladesh reveals both significant improvements and persistent vulnerabilities in South Asian food security from 2000 to 2025. Bangladesh has achieved the most rapid nutritional improvement, halving child stunting in less than two decades, through sustained institutional innovation in targeting and delivery. India's Green Revolution productivity gains are increasingly threatened by soil degradation, groundwater depletion, and the nutritional inadequacy of a cereal-dominated food system. Pakistan has experienced deteriorating food security indicators across almost every dimension despite nominal policy ambition, driven by governance failures, fiscal constraints, and climate shocks. The NARDL and GARCH analyses confirm that food security in all three countries is characterized by asymmetric price transmission and increasing volatility, with structural breaks coinciding with the 2007–08 global food crisis and the COVID-19 pandemic, underscoring the need for more robust buffers against external shocks.

Q19: Food Waste among Young Consumers in Developing Countries (Chapter 20)

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Food waste among university students in developing countries including Pakistan is driven by the interaction of economic factors (subsidized pricing that reduces the perceived cost of waste), behavioral factors (overestimation of appetite, impulsive food selection, poor meal planning), attitudinal factors (awareness of waste consequences does not automatically translate into waste-reducing behavior), institutional factors (fixed portion sizes, inflexible meal plans, absence of waste reduction programs), and sociodemographic factors (younger consumers and higher-income households waste more). Effective reduction strategies combine institutional reforms (trayless dining, portion control, food redistribution systems) with behavioral nudges (default smaller portions, awareness campaigns, social norm messaging) and economic incentives (cost-reflective pricing, waste-based fees). The broader significance is systemic: food waste reduces effective food availability, amplifies environmental pressure, and contributes to the food security deficit in countries where millions simultaneously lack adequate food and institutions waste substantial quantities of it.

Q20: Insects and Food Security in Developing Economies (Chapter 21)

Insects occupy a genuinely dual position in food security: pest damage and storage losses remove a substantial share of the food developing economies produce, while edible insects remain an underused, nutrient-dense, resource-efficient food and feed source. Which face predominates is an institutional question rather than a biological one: where extension, quarantine, and regulatory capacity are strong, as in Thailand's cricket-farming sector, losses are contained and opportunities captured. In Pakistan, illustrated by the 2019–2021 desert locust upsurge, weak extension delivery, fragmented quarantine authority, and an absent regulatory pathway for insect-based products leave both pathways underperforming. Converting insects into an asset requires surveillance, integrated pest management, and a regulatory foundation for insect-based food and feed.

Q21: Comparative Policy Performance Across South Asia, Sub-Saharan Africa, and MENA (Chapter 22)

Institutional quality, measured through the Worldwide Governance Indicators' six dimensions, explains why comparable policies perform differently across South Asia, Sub-Saharan Africa, and MENA. South Asia's digital democracies benefit from civic participation but face bureaucratic inertia. Sub-Saharan Africa, despite resource constraints, has produced innovative, often leapfrogging administrative solutions in countries such as Rwanda, Kenya, and Ghana. MENA's centralized planning, exemplified by Saudi Vision 2030, has accelerated modernization but still requires more inclusive institutions. No single governance model transfers wholesale across these contexts; innovations travel successfully only where institutional compatibility and context-specific adaptation are built into the transfer process.

2. Practical Implications for Policymakers, NGOs, Development Practitioners, and Researchers

The analysis in this volume yields ten concrete, actionable implications. They are addressed simultaneously to national governments, international development organizations, NGOs and civil society, and academic researchers, since effective food security reform requires all of these actors working in alignment.

2.1. Treat institutional reform as the primary investment priority

No food security intervention, improved seeds, cash transfers, nutrition programs, digital extension services, can compensate for weak institutions. The priority investment must be building the governance capacity to design, implement, monitor, and adapt food security policies. This means civil service reform targeted at food governance functions, data system infrastructure that is interoperable across agencies and levels of government, accountability mechanisms with real enforcement, and multi-stakeholder governance structures that give civil society, farmers, and nutrition experts formal roles in policy debate. Development partners must condition program support on institutional development, not merely on technical compliance with program targets.

2.2. Design for political economy, not against it

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Technically optimal food security policies that ignore political economy will fail at implementation. Effective reform begins with an honest assessment of who benefits from the status quo and what it will take to build a coalition for change. This means sequencing reforms to protect losers first, providing alternative income support before dismantling the subsidies transitional losers depend on, and building political coalitions around the beneficiaries of change. The political sociology of food security reform is as important as the economics of food system design.

2.3. Integrate marine and terrestrial food security governance

No national food security policy is complete without a coherent marine food security strategy. Coastal developing countries should adopt the GMFSI as a diagnostic tool, align fisheries governance with food security objectives, invest in sustainable aquaculture development, integrate seaweed into national nutrition programs and school feeding schemes, and develop blue economy governance frameworks that explicitly address the food security implications of fisheries depletion, marine pollution, and climate-driven habitat loss. The systematic marginalization of marine food systems in food security policy represents a correctable blind spot.

2.4. Decentralize with discipline: match authority with finance, capacity, and accountability

The evidence from six country comparisons is unambiguous: devolution of food governance authority without matched finance, administrative capacity, accountability structures, and national minimum standards produces fragmentation rather than responsiveness. Governments devolving food security functions must simultaneously invest in local administrative capacity, establish formula-based fiscal transfer systems that account for food security burden and local fiscal effort, create enforceable national minimum standards for food security service delivery, and build participatory accountability mechanisms, social audits, grievance systems, beneficiary registries, that enable communities to hold local institutions accountable for results.

2.5. Replace regressive subsidies with targeted, adaptive social protection

The evidence from India, Egypt, Pakistan, Indonesia, Nigeria, and Brazil consistently shows that universal or poorly targeted food subsidies, procurement monopolies, and retail price controls are regressive in their distributional incidence, fiscally unsustainable, and less effective at protecting the food security of the poor than well-designed targeted social protection. The transition from regressive subsidy regimes to targeted systems requires political strategy, sequenced implementation, compensation for transitional losers, and transparent communication, as well as the technical infrastructure of functional beneficiary registries, digital delivery systems, and rapid scaling capacity for emergency deployment during price shock episodes.

2.6. Build climate adaptation into food security architecture now, not later

Climate change is not a future risk to be incorporated into the next cycle of food security planning: it is a current driver of food insecurity operating in every country represented in this volume. National food security strategies must embed climate-smart agriculture, climate-resilient fisheries and aquaculture management, adaptive social protection systems with pre-defined climate triggers, and subnational food security planning that accounts for local agroecological vulnerability. Countries with high climate exposure for example Pakistan, Bangladesh, Tanzania, sub-Saharan African states should treat the integration of climate adaptation into food security architecture as an immediate governance priority and should leverage NDC commitments and Paris Agreement financing mechanisms to access international climate finance for integrated agri-climate programs.

2.7. Invest in food system data infrastructure as a public good

Many of the governance failures documented in this volume, i.e. leakage, targeting errors, corruption, adaptive failure, algorithmic bias, are functions of information deficits. Governments, development partners, and academic institutions should jointly invest in integrated food system data platforms that are interoperable across agencies, accessible to civil society, designed to make the most vulnerable populations legible rather

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than invisible, and governed by transparent data sovereignty frameworks that prevent the concentration of food security information in private or foreign-controlled systems. Critically, data systems must be co-designed with the communities and policymakers who will use them, not by external technical agencies operating at a distance from the governance realities they are meant to inform.

2.8. Use trade policy as a rules-based system, not an emergency lever

Export bans and import restrictions used as first responses to domestic food price crises consistently amplify rather than dampen volatility for trading partners and, ultimately, for domestic producers through reduced long-run investment incentives. South Asian and other developing country governments should negotiate and commit to rules-based frameworks, with pre-agreed triggers, transparency requirements, and automatic sunset clauses, for when and how trade restrictions can be applied. Regional food reserve mechanisms, diversified import sourcing strategies, and domestic supply chain resilience investment are higher-return substitutes for trade restrictions as mechanisms for buffering domestic food markets against international price shocks.

2.9. Centre gender equity and the most marginalized in food system redesign

Women are the majority of small-scale food producers, fish processors, and seaweed farmers in coastal developing economies; the primary managers of household food security; and consistently among the most severely affected by food price shocks, climate impacts, and governance failures. Yet food security policies consistently marginalize women's participation in governance, their access to land and credit, and their voice in program design. Institutional redesign must explicitly include gender equity as a core objective not a cross-cutting theme to be noted in program documents and implemented nowhere. This requires gender-disaggregated data collection, women's representation on food governance bodies, gender-sensitive extension services and social protection, and land and property rights reform that gives women secure tenure.

2.10. Build a culture of evidence, experimentation, and double-loop learning in food governance

The most important institutional investment in food security governance is the culture and capacity for learning. Food governance institutions that practice only single-loop learning, adjusting implementation to improve efficiency within existing policy frameworks, will remain locked in dysfunctional equilibria as the world changes around them. The transition to double-loop learning, questioning whether the right goals are being pursued, and triple-loop learning, questioning whether the learning mechanisms themselves are appropriately designed, requires autonomous learning institutions (research bodies, independent evaluation agencies, civil society monitoring organizations), broad multi-stakeholder deliberation in policy design, and transparent science-policy interfaces that make evidence accessible and contestable. The IFPRI Kaleidoscope Model identifies this learning infrastructure as the most powerful determinant of long-run policy durability.

3. Limitations and Directions for Future Research

This volume has several important limitations that point toward productive future research directions.

The first is geographical concentration. Despite the breadth of the volume's coverage, the empirical evidence is weighted toward South Asia particularly Pakistan, India, and Bangladesh and toward selected countries in sub-Saharan Africa, Southeast Asia, and Latin America. The food security governance challenges and institutional configurations of Central Asia, the Pacific Island states, West Africa's Sahel zone, and the small island developing states are underrepresented. Extending the frameworks developed here to these regions would significantly strengthen the generalizability of the conclusions.

The second is the treatment of gender. Gender appears throughout the volume as a dimension of vulnerability, inequality, and marginalization, but the volume does not contain a dedicated chapter conducting systematic gender analysis of food security governance. The political economy of gendered power within food systems, from land tenure through extension services to procurement networks and community food governance, deserves a dedicated volume. Future research should examine how gender

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dynamics shape the institutional failures documented here and what governance reforms are most effective at centering women's food security in policy design and implementation.

The third concerns GMFSI. The Global Marine Food Security Index proposed in Chapter 7 is a conceptual framework awaiting operationalization. Developing the GMFSI into a quantified, internationally comparable index, with agreed indicators, measurement protocols, ground-truthing methodologies, and data collection infrastructure, represents a major research agenda for marine food security scholars, FAO's Fisheries and Aquaculture Division, and national fisheries statistical agencies.

The fourth is the limited integration of food waste analysis into the volume's broader governance framework. Chapter 20 provides a rigorous analysis of food waste behavior in educational institutions, but the connections between post-consumer waste, value chain governance, market integration, and national food security policy remain underdeveloped. A future volume addressing food loss and waste as a food security governance problem from field losses through cold chain gaps to consumer plate waste would complement this volume's production and access focus.

The fifth concerns measurement and methodology. Several chapters construct or propose composite indices and econometric models that require further empirical validation across diverse country contexts. The National Food Security Index constructed in Chapter 19, the GMFSI proposed in Chapter 7, and the governance framework developed in Chapter 4 all require longitudinal empirical testing, cross-country calibration, and refinement through engagement with national statistical systems and in-country research partners.

4. Closing Argument

The world does not lack food security knowledge. It lacks food security governance. Decades of investment in agricultural research, nutritional science, econometric analysis, policy advisory processes, and international development assistance have produced an analytical literature of extraordinary depth and sophistication, a literature represented, in its diversity and geographic reach, by the twenty-two chapters of this volume. What that literature has not yet produced, what this book hopes to contribute to producing, is a rigorous, integrated, politically grounded framework for understanding why good knowledge so rarely becomes good policy, and what conditions make the translation of evidence into governance change possible.

The scale of the challenge is large: 733 million people chronically hungry, 2.3 billion food insecure, planetary boundaries under pressure from food system emissions and resource depletion, climate disruption accelerating, marine ecosystems degrading, and food waste consuming approximately one-third of all food produced for human consumption. But so too is the evidence base for what works. Bangladesh halved child stunting in less than two decades through sustained institutional innovation in targeting and delivery. Brazil took itself off the FAO hunger map through the multi-stakeholder governance architecture of Fome Zero and CONSEA. India eliminated tens of millions of ghost beneficiaries from its ration system through biometric authentication. Indonesia is integrating its world-leading seaweed industry into national nutrition policy. Ethiopia built one of the developing world's most sophisticated social protection systems through community-based targeting and institutional investment. These are not miracles. They are the product of governance reform, political commitment, institutional investment, and above all, the willingness to treat food security as what it has always been: a political achievement, not merely an agricultural one.

The chapters in this volume are united by a conviction that the most important contribution a food security scholar can make is not a better estimate of a price elasticity, a more precise measure of stunting prevalence, or a more efficient supply chain algorithm, important as all of these are, but a clearer account of why good designs fail and what makes durable progress possible. If this book contributes, even modestly, to building that understanding, it will have served its purpose.

Declaration: AI-assisted tools (LLMs) were used to improve the language and grammar of this chapter. The authors reviewed and approved all content and assume full responsibility for its accuracy.

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ABOUT THE BOOK

This book brings together cutting-edge research and practical insights from scholars, policymakers, and practitioners across the Global South to rethink food security policy in developing countries.

It argues that while agriculture is essential, the real challenge lies in governance—how decisions are made, institutions are designed, resources are allocated, and power is exercised.

Through multidisciplinary perspectives and country experiences, this book offers evidence-based pathways for building inclusive, resilient, and sustainable food systems that leave no one behind.

KEY THEMES COVERED

- Governance and Institutions
- Equity and Social Inclusion
- Evidence and Policy Learning
- Sustainable Food Systems
- Climate Change and Resilience
- Policy Coherence and Leadership

ABOUT THE EDITORS

Dr. Muhammad Khalid Bashir is a distinguished academic, researcher, and policy expert specializing in agricultural economics, food security, climate change, and rural development. With more than two decades of experience in teaching, research, and policy engagement, he has made significant contributions to advancing evidence-based solutions for sustainable agriculture and food systems in Pakistan and beyond. His research has informed food security policies, nutrition initiatives, and rural development strategies. His scholarly excellence has been recognized through the HEC Best Research Paper Award, HEC Best Young Researcher Award, the Pakistan Council for Science and Technology (PCST) Productivity Award, and the Express Media Group Teaching Award. He has also been recognized among the Top 1% of Reviewers worldwide by Clarivate, reflecting his international academic standing and commitment to research excellence.

Dr. Muhammad Umar Farrukh is an economist, academic, and researcher specializing in food security, agricultural economics, development economics, public policy, and sustainable economic growth. As an Assistant Professor of Economics, he is actively engaged in teaching, research, and policy-oriented initiatives addressing contemporary development challenges. His research explores the relationships among food systems, governance, rural transformation, and economic resilience, with particular emphasis on developing countries. He has contributed to evidence-based policymaking by examining strategies that strengthen food security, promote agricultural sustainability, enhance institutional effectiveness, and support inclusive development. His work advocates innovative approaches integrating governance, technological advancement, and human capital development to build resilient food systems and foster sustainable economic prosperity. Dr. Farrukh remains committed to producing impactful research that informs policy and improves livelihoods.

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